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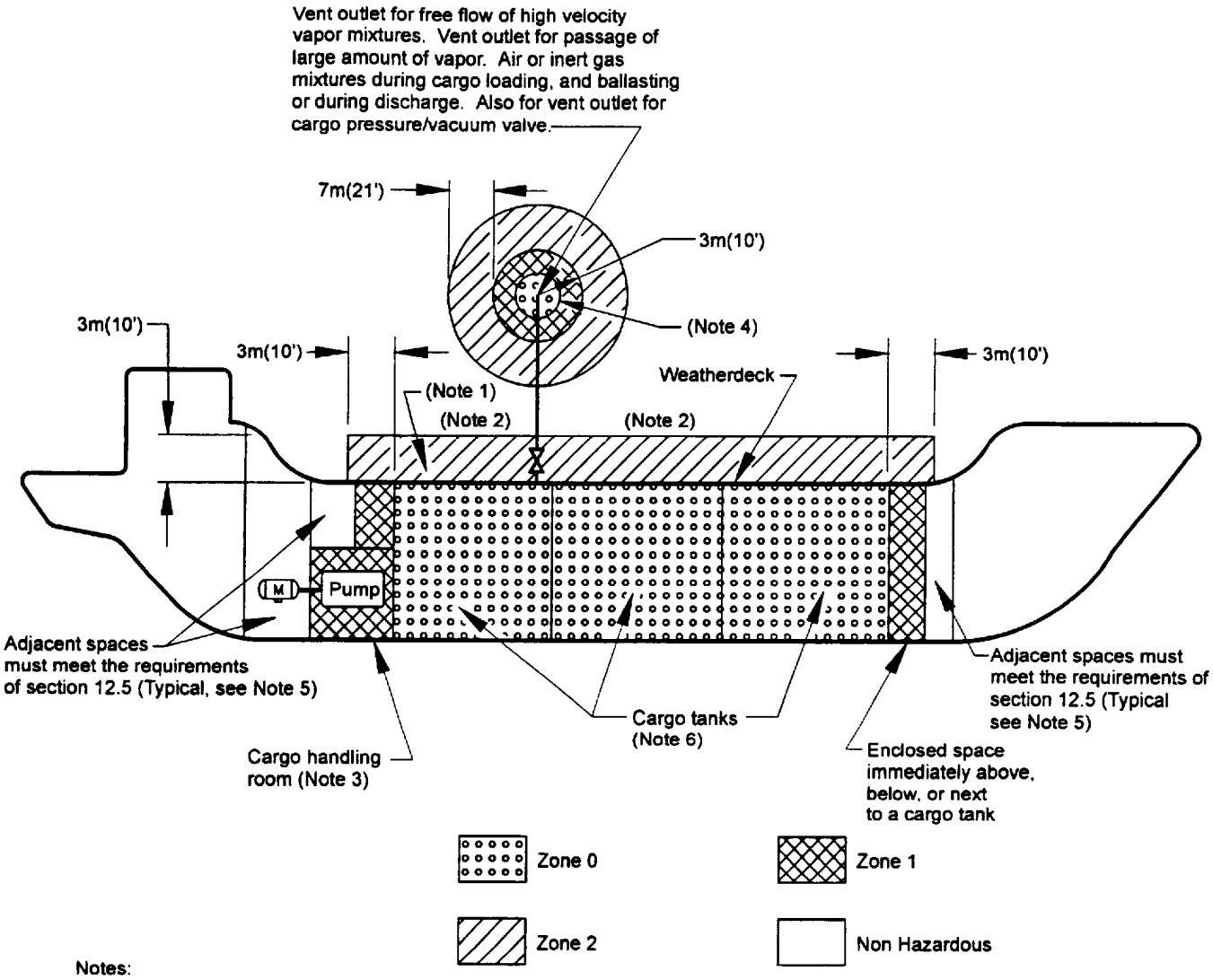
ERRATA

The following figures are replaced by the next three pages:
Page 86, Figure 90
Page 87, Figure 91 and
Page 88, Figure 92.

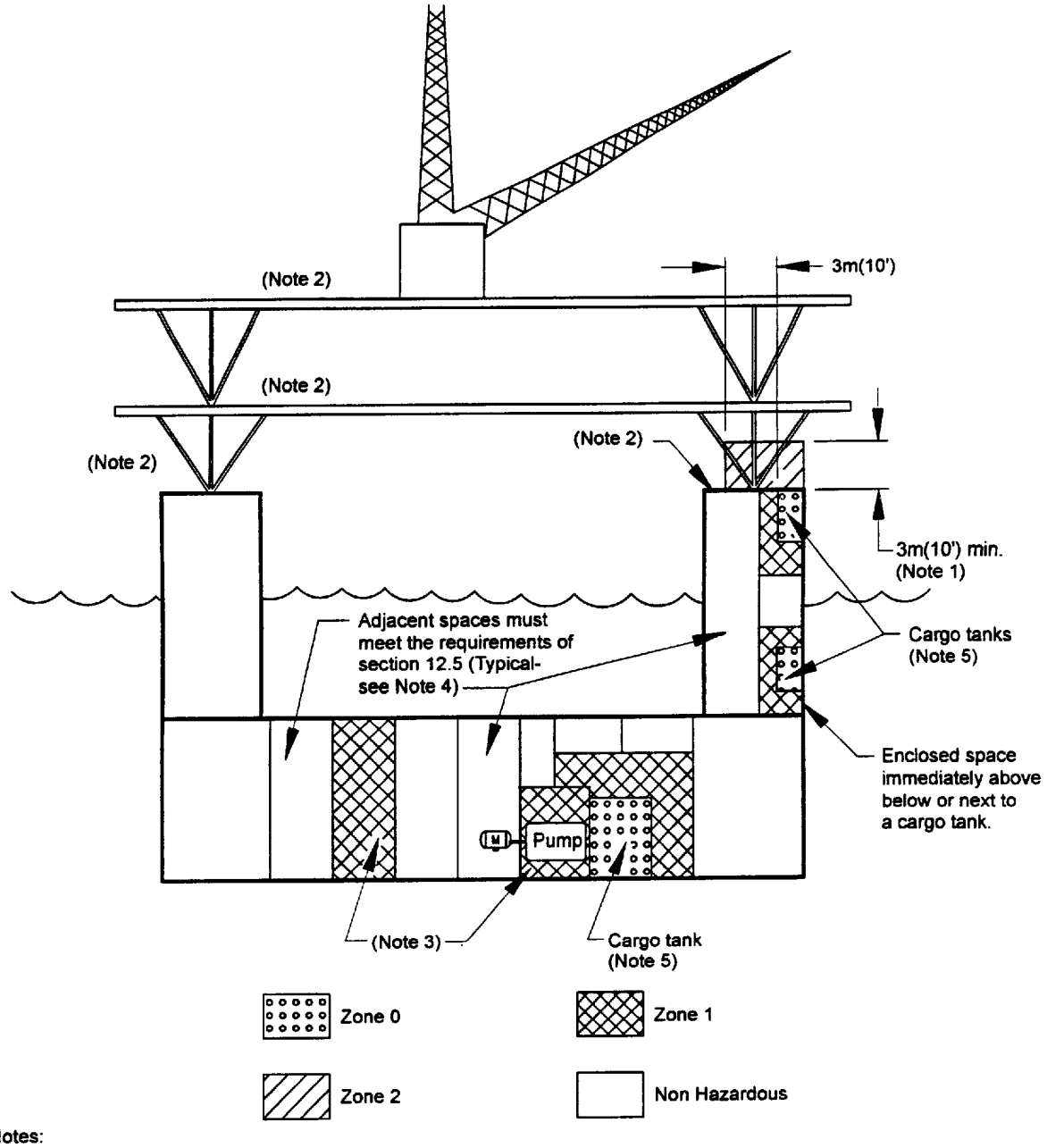


Notes:

1. This area classified due to proximity to cargo tanks.
2. Areas more than 3m(10') above the weatherdeck are unclassified except as required by this document for production equipment contained therein.
3. Space must be:
   a) continuously ventilated at $\geq$ 20 air changes per hour, and
   b) loss of ventilation must be alarmed in a manned space, and
   c) combustible gas detection must be installed in accordance with section 6.5.2 .

   or, If ventilated <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.
4. An area 1 meter (3 feet) around vent is classified Zone 0.
5. All spaces are subject to the adjacent space requirements of section 12.5.
6. Cargo is defined as a flammable gas or vapor or flammable or combustible liquid with a flashpoint below 60°C(140°F)

Figure 90—Typical Floating Production Storage and Offloading Unit (FPSO)
(See Section 12.2.1)

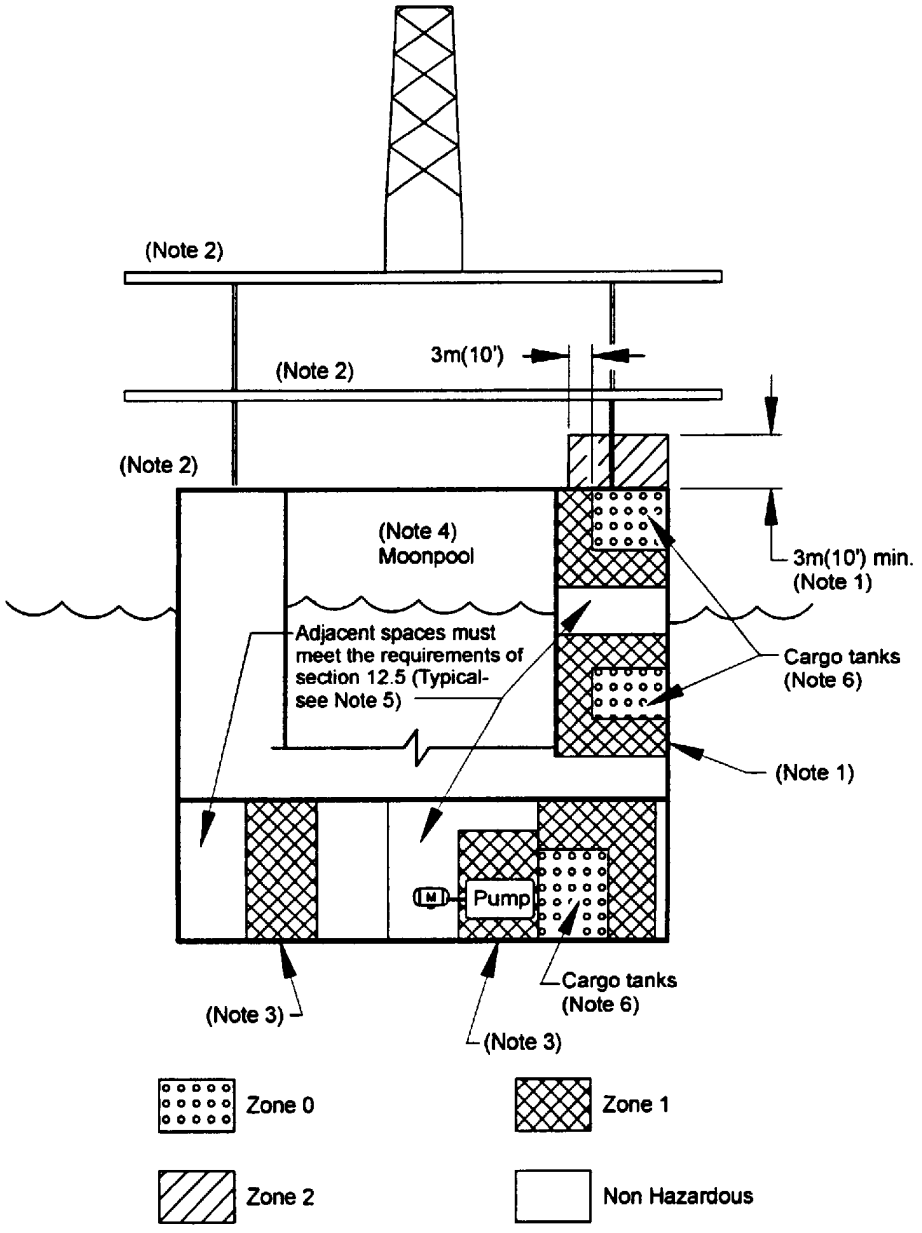


Notes:

1. This area classified due to proximity to cargo tanks.
2. Areas more than 3m(10') above the weatherdeck are unclassified except as required by this document for production and drilling equipment contained therein.
3. Space containing processing equipment or natural gas fueled prime mover with all flammable liquid or gas vents extended to the outside of the area are classified Zone 1 if:
   a) continuously ventilated at ≥20 air changes per hour, and
   b) loss of ventilation must be alarmed in a manned space, and
   c) combustible gas detection must be installed in accordance with section 6.5.2 .

   or, If ventilated <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.
4. All spaces are subject to the adjacent space requirements of section 12.5.
5. Cargo is defined as a flammable gas or vapor or flammable or combustible liquid with a flashpoint below 60°C(140°F)

Figure 91—Typical Tension Leg Platform (TLP)
(See Section 12.3.1)



Notes:

1. This area classified due to proximity to cargo tanks.
2. Areas more than 3m(10') above the weatherdeck are unclassified except as required by this document for production and drilling equipment contained therein.
3. Space containing processing equipment or natural gas fueled prime mover with all flammable liquid or gas vents extended to the outside of the area are classified Zone 1 if:
   a) continuously ventilated at ≥ 20 air changes per hour, and
   b) loss of ventilation must be alarmed in a manned space, and
   c) combustible gas detection must be installed in accordance with section 6.5.2 .

   or, If ventilated <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.
4. Moonpool area is unclassified if it contains all welded closed piping or continuous metallic tubing systems without valves flanges or similar devices, and is not within the hazardous area created by adjacent equipment.
5. All spaces are subject to the adjacent space requirements of section 12.5.
6. Cargo is defined as a flammable gas or vapor or flammable or combustible liquid with a flashpoint below 60°C(140°F)

Figure 92—Typical Spar, Caisson, or Similar Unit
(See Section 12.4.1)

STD.API/PETRO RP 505-ENGL 1997 ■ 0732290 0600578 631 ■

Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

API RECOMMENDED PRACTICE 505
FIRST EDITION, NOVEMBER 1997

STEP
Strategies for Today's Environmental Partnership

American Petroleum Institute

Strategies for Today's Environmental Partnership

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- To operate our plants and facilities, and to handle our raw materials and products in a manner that protects the environment, and the safety and health of our employees and the public.
- To make safety, health and environmental considerations a priority in our planning, and our development of new products and processes.
- To advise promptly, appropriate officials, employees, customers and the public of information on significant industry-related safety, health and environmental hazards, and to recommend protective measures.
- To counsel customers, transporters and others in the safe use, transportation and disposal of our raw materials, products and waste materials.
- To economically develop and produce natural resources and to conserve those resources by using energy efficiently.
- To extend knowledge by conducting or supporting research on the safety, health and environmental effects of our raw materials, products, processes and waste materials.
- To commit to reduce overall emissions and waste generation.
- To work with others to resolve problems created by handling and disposal of hazardous substances from our operations.
- To participate with government and others in creating responsible laws, regulations and standards to safeguard the community, workplace and environment.
- To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes.

STD.API/PETRO RP 505-ENGL 1997 ■ 0732290 0600580 29T ■

Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

Exploration and Production Department
Manufacturing, Distribution and Marketing Department

API RECOMMENDED PRACTICE 505
FIRST EDITION, NOVEMBER 1997

American Petroleum Institute

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FOREWORD

This Recommended Practice is under the joint jurisdiction of the API Exploration and Production (E&P) Department Committee on Production Equipment Standards, the API Manufacturing Distribution and Marketing (MDM) Department, Committee on Refinery Equipment, and the Pipeline Operations Technical Committee. It is based upon a level of knowledge gained through experience and through the successful application of this practice in the refining, drilling and producing, and pipeline segments of the petroleum industry.

Recommended Practice 505 was prepared as a supplement to the 1996 Edition of the National Electrical Code (NEC) Article 505, with a scope limited to those petroleum facility locations classified as Class I, Zone 0, Zone 1, and Zone 2. Efforts were coordinated with the work of the ISA SP12 committee, which concurrently normalized the International Electrotechnical Commission (IEC) Standard 79-10 that addresses the zone area classification scheme in general. RP 505 will serve the petroleum industry, essentially as an supplement to both ISA 12.24.01 (IEC 79-10 Mod) and NEC Article 505. RP 500 is presently referenced by Article 500 of the NEC; it is anticipated that the 1999 NEC will also reference RP505 in Article 505.

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Suggested revisions are invited and should be submitted to the director of the Manufacturing, Distribution and Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2

1 Scope

1.1 PURPOSE

1.1.1 The purpose of this recommended practice is to provide guidelines for classifying locations Class I, Zone 0, Zone 1, and Zone 2 locations at petroleum facilities for the selection and installation of electrical equipment. Basic definitions given in the 1996 edition of NFPA 70, the National Electrical Code (NEC), have been followed in developing this recommended practice. This publication is only a guide and requires the application of sound engineering judgment.

Note: Recommendations for determining the degree and extent of classified locations Class I, Division 1 and Division 2 are addressed in API RP 500, Recommended Practice for Classification of Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2.

1.1.2 Electrical installations in areas where flammable liquids, gases, or vapors are produced, processed, stored or otherwise handled can be suitably designed if the locations of potential sources of release and accumulation are clearly defined. Once a location has been classified, requirements for electrical equipment and associated wiring should be determined from applicable publications. Applicable publications may include NFPA 70 (NEC) or API RP 14F. Reference Section 2 for publications for other possible applications.

1.2 SCOPE

1.2.1 This document applies to the classification of locations for both temporarily and permanently installed electrical equipment. It is intended to be applied where there may be a risk of ignition due to the presence of flammable gas or vapor, mixed with air, under normal atmospheric conditions. Normal atmospheric conditions are defined as conditions that vary above and below reference levels of 101.3 kPa (14.7 psia) and 20°C (68°F) provided that the variations have a negligible effect on the explosion properties of the flammable materials.

The following items are beyond the scope of this document:

a. Piping systems used for odorized natural gas used as fuel for cooking, heating, air conditioning, laundry and similar appliances;
b. catastrophes such as well blowouts or process vessel ruptures. Such extreme events are not predictable and require emergency measures at the time of occurrence;
c. the suitability of locations for the placement of non-electrical equipment;
d. classification for locations containing combustible dust, ignitible fibers, or flyings;
e. installations underground in mines;
f. areas for the processing and manufacture of explosives; and,
g. areas where the presence of flammable mist may give rise to an unpredictable risk and that require special consideration.

1.2.2 Recommendations for determining the degree and extent of classified locations for specific examples of situations commonly encountered in petroleum facilities are given in Sections 8 through 14. While it is important for area classifications at refineries, production and drilling facilities, and pipeline facilities to agree to some extent, there are differences in production, drilling, transportation and refining facilities. Some differences include the process conditions, types and quantities of products handled, the physical size of typical facilities, and varying housing and sheltering practices.

1.2.3 Section 8 includes applications that are common to several of the facility types described in Sections 9 through 14.

1.2.4 Section 9 is applicable to locations in which flammable petroleum gases and vapors and volatile flammable liquids are processed, stored, loaded, unloaded, or otherwise handled in petroleum refineries.

1.2.5 Section 10 is applicable to locations surrounding oil and gas drilling and workover rigs and production facilities on land and on marine fixed (bottom-founded, non-floating) platforms where flammable petroleum gas and volatile liquids are produced, processed (for example, compressed), stored, transferred (for example, pumped), or otherwise handled prior to entering the transportation facilities.

1.2.6 Section 11 is applicable to locations on Mobile Offshore Drilling Units (MODUs).

1.2.7 Section 12 is applicable to locations surrounding oil and gas drilling and workover rigs and production facilities on floating production units (FPUs) such as, but not limited to, tension leg platforms (TLPs), floating production systems (FPSs), floating production systems with off-loading (FPSOs), single anchor leg mooring buoys (SALMs), caisson structures, spars, and other floating structures where flammable petroleum gas and volatile liquids are produced, processed (for example, compressed), stored, transferred (for example, pumped) or otherwise handled prior to entering the transportation facilities.

1.2.8 Section 13 is reserved for future use.

1.2.9 Section 14 is applicable to onshore and offshore facilities handling the delivery of flammable or combustible petroleum liquids or flammable gases. Pipeline facilities may

include pump and compressor stations, storage facilities, manifold areas, valve sites and pipeline right-of-way areas.

2 References

2.1 INDUSTRY CODES, GUIDES, AND STANDARDS

Various organizations have developed numerous codes, guides and standards that have substantial acceptance by industry and governmental bodies. Codes, guides, and standards useful in the classification of locations and in the design and installation of electrical systems are listed below. These references are not to be considered a part of this recommended practice except for those specifically referenced.

API

API RP 2G	*Recommended Practice for Production Facilities on Offshore Structures*
API RP 11S3	*Recommended Practice for Electric Submersible Pump Installations*
API RP 14C	*Recommended Practice for Analysis Design Installation and Testing of Basic Surface Safety Systems on Offshore Production Platforms*
API RP 14F	*Recommended Practice for Design and Installation of Electrical Systems for Offshore Production Platforms*
API RP 14G	*Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms*
API RP 500	*Recommended Practice for Classification of Locations for Electrtical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*
API RP 521	*Guide for Pressure-Relieving and Depressuring Systems*
API RP 540	*Recommended Practice for Electrical Installations in Petroleum Processing Plants*
API Pub 4322	*Fugitive Hydrocarbon Emissions from Petroleum Production Operations, Volume I and Volume II*
API Pub 4589	*Fugitive Hydrocarbon Emissions from Oil and Gas Production Operations*
API Pub 4615	*Emission Factors for Oil and Gas Production Operations*
API PSD 2216	*Ignition Risk of Hot Surfaces in the Open Air*

ABS[1]

Rules for Building and Classing Mobile Offshore Drilling Units

Rules for Building and Classing Steel Vessels

AGA[2]

XF0277 *Classification of Gas Utility Areas for Electrical Installations*

ANSI[3]

C2 *National Electrical Safety Code (NESC)*

ASHRAE[4]

ASHRAE Fundamentals Handbook

ASTM[5]

D-323-82 *Standard Test Method for Vapor Pressure Of Petroleum Products (Reid Method)*

CSA[6]

Hazardous Locations—Guide for the Design, Testing, Construction, and Installation of Equipment in Explosive Atmospheres, John A. Bossert

C22.1 *Canadian Electrical Code, Part I*

IEC[7]

IEC 50 (426)	*(1990), International Electrotechnical Vocabulary (IEV)—Chapter 426—Electrical apparatus for explosive atmospheres*
IEC 79-1A	*(1975-Amendment No. 1, 1993), Construction and verification tests of flameproof enclosures of electrical apparatus*
IEC 79-2	*(1983), Electrical apparatus for explosive gas atmospheres—Part 2: Electrical apparatus, type of protection "p"*
IEC 79-3	*(1990), Electrical apparatus for explosive gas atmospheres—Part 3: Spark-test apparatus for intrinsically-safe circuits*
IEC 79-4	*(1975), Electrical apparatus for explosive gas atmospheres—Part 4: Method of test for ignition temperature*
IEC 79-4A	*(1970), First supplement to IEC 79-4 (1966)*
IEC 79-10	*Electrical apparatus for explosive gas atmospheres—Part 10: Classifications of hazardous areas*
IEC 79-11	*(1991), Electrical apparatus for explosive gas atmospheres—Part 11: Intrinsic safety "i"*

[1]American Bureau of Shipping, Two World Trade Center, 106th Floor, New York, New York 10048.

[2]American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209

[3]American National Standards Institute, 11 West 42 Street, New York, New York 10036.

[4]American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, Georgia 30329.

[5]American Society of Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428.

[6]Canadian Standards Association, 178 Rexdale Boulevard, Etobicoke (Toronto), Canada, M9W 1R3.

[7]International Electrotechnical Commission, 3 rue de Varembé, P.O. Box 131, 1211 Geneva 20, Switzerland

IEC 79-12 *1978), Classification of mixtures of gases or vapours with air according to their maximum experimental safe gaps and minimum igniting currents*

IEC 79-13 *(1982), Electrical apparatus for explosive gas atmospheres—Part 13: Construction and use of rooms or buildings protected by pressurization*

IEC 79-20 *(1995), Electrical apparatus for explosive gas atmospheres—Part 20: Data for flammable gases and vapours, relating to the use of electrical apparatus*

IEEE[8]

Std. 45 *Recommended Practice for Electrical Installations on Shipboard*

IP[9]

IP 15 *Model Code of Safe Practice in the Petroleum Industry, Part 15: Area Classification Code for Petroleum Installations*

ISA[10]

ISA RP 12.1.01 *Definitions and Information Pertaining to Electrical Instruments in Hazardous Locations*

ISA S12.4 *Instrument Purging for Reduction of Hazardous Area Classification*

ISA RP 12.6 *Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations*

ISA S12.13 *Part I, Performance Requirements, Combustible Gas Detectors*

ISA RP 12.13 *Part II, Installation Operation and Maintenance of Combustible Gas Detection Instruments*

Note: Includes former Bureau of Mines Bulletin 627, Flammability Characteristics of Combustible Gases and Vapors (no longer in print).

ISA RP 12.24.01 (IEC 79-10 Mod.) *Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous (Classified) Locations*

ISA S51.1 *Process Instrumentation Technology*

Electrical Systems for Oil and Gas Production Facilities, David N. Bishop

Electrical Instruments in Hazardous Locations, Ernest C. Magison

NFPA[11]

NFPA 30 *Flammable and Combustible Liquids Code*

NFPA 37 *Standard for Stationary Combustion Engines and Gas Turbines*

NFPA 54 *Fuel Gas Code*

NFPA 69 *Explosion Prevention System*

NFPA 70 *National Electrical Code*

NFPA 70B *Recommended Practice for Electrical Equipment Maintenance*

NFPA 70E *Electrical Safety Requirements for Employee Workplace*

NFPA 90A *Standard for the Installation of Air Conditioning and Ventilating Systems*

NFPA 91 *Standard for Exhaust Systems for Air Conveying of Materials*

NFPA 325 *Guide to Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*

NFPA 496 *Standard for Purged and Pressurized Enclosures for Electrical Equipment*

NFPA 497 *Recommended Practice for Classification of Class I Hazardous (Classified) Locations For Electrical Installations In Chemical Process Areas*

Electrical Installations in Hazardous Locations, P. J. Schram and M. W. Earley

UL[12]

UL Technical Report No. 58 *An Investigation of Flammable Gases or Vapors with Respect to Explosion-proof Electrical Equipment*

UL 913 *Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III Division 1 Hazardous (Classified) Locations*

2.2 GOVERNMENT CODES, RULES, AND REGULATIONS

Federal regulatory agencies have established certain requirements for the design, installation, and operation of petroleum facilities. These requirements may influence the design, installation and operation of the electrical systems. In addition to federal regulations, certain state, municipal, and local regulations may be applicable. The documents identified below may pertain to petroleum operations and should be referenced when applicable.

CFR[13]

29 *Code of Federal Regulations* Part 1910, Occupational Safety and Health Standards Subpart H. Process Safety Management of Highly Hazardous Chemicals

[8]Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, New Jersey 08855-1331

[9]The Institute of Petroleum, London, 61 New Cavendish Street, London W1M 8AR, England.

[10]Instrument Society of America, 67 Alexander Drive, Research Triangle Park, North Carolina 27709.

[11]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

[12]Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, Illinois 60062-2096.

[13]Code of Federal Regulations, *The Code of Federal Regulations* is available from the U.S. Government Printing Office, Washington, D.C. 20402.

29 *Code of Federal Regulations* Part 1910, Occupational Safety and Health Standards Subpart K. Electrical Construction (Occupational Safety and Health Administration)
29 *Code of Federal Regulations* Part 1910, Occupational Safety and Health Standards, Subpart S, Electrical (Occupational Safety and Health Administration)
30 *Code of Federal Regulations* Part 250, Oil and Gas and Sulphur Operation in the Outer Continental Shelf (United States Department of the Interior, Minerals Management Service)
33 *Code of Federal Regulations* Subchapter N, Outer Continental Shelf Activities Parts 140 through 147 (United States Coast Guard)
46 *Code of Federal Regulations* Shipping Subchapter I-A, Parts 107-108, Mobile Offshore Drilling Units (United States Coast Guard)
46 *Code of Federal Regulations* Shipping Subchapter J, Electrical Engineering, Parts 110 through 113 (United States Coast Guard)
49 *Code of Federal Regulations* Pipeline Safety Regulations Parts 190, 191, 192, 193, and 195 (United States Department of Transportation)

3 Acronyms and Abbreviated Definitions

3.1 ACRONYMS

This recommended practice includes acronyms within the text. These acronyms are defined as follows:

ABS	American Bureau of Shipping
ACT	Automatic Custody Transfer
ANSI	American National Standards Institute
API	American Petroleum Institute
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BOP	Blow Out Preventer
CSA	Canadian Standards Association
DOT	Department of Transportation
FM	Factory Mutual Research Corporation
FPS	Floating Production System
FPSO	Floating Production Storage Offloading
FPU	Floating Production Unit
HVL	Highly Volatile Liquid
IEEE	Institute of Electrical and Electronics Engineers
IMO	International Maritime Organization
ISA	Instrument Society of America
LEL	Lower Explosive Limit (LFL preferred)
LFL	Lower Flammable Limit
MESG	Maximum Experimental Safe Gap
MIC	Minimum Ignition Current
MMS	Minerals Management Service, U.S. Department of the Interior
MODU	Mobile Offshore Drilling Unit
NEC	National Electrical Code
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
NPL	Neutral Pressure Level
SALM	Single Anchor Leg Mooring (buoy)
TFL	Through Flow Line
TLP	Tension Leg Platform
UEL	Upper Explosive Limit (UFL preferred)
UFL	Upper Flammable Limit
UL	Underwriters Laboratories, Inc.
USCG	United States Coast Guard

3.2 DEFINITIONS

When definitions are extracted from other publications and modified, the format (Reference XX, Mod) is used—for example, (IEC 79-10, Mod) indicates that the definition was extracted from the publication IEC 79-10, but with the text modified. For the purposes of this recommended practice the following definitions apply:

3.2.1 approved: acceptable to the authority having jurisdiction.

3.2.2 area: see "location."

3.2.3 associated apparatus: apparatus used in intrinsically safe systems in which the circuits are not necessarily intrinsically safe themselves, but affect the energy in the intrinsically safe circuits and are relied upon to maintain intrinsic safety. Reference NEC Article 504-2 for additional details.

3.2.4 Reserved for future use.

3.2.5 Reserved for future use.

3.2.6 Reserved for future use.

3.2.7 Reserved for future use.

3.2.8 boiling point: The temperature of a liquid boiling at an ambient pressure of 101.3 kPa (1,013 mbar). (IEC 79-10, Mod)

3.2.9 building, purged: see Enclosure, Purged.

3.2.10 Classification

3.2.10.1 Class I, Zone 0: A Class I, Zone 0 location is a location (1) in which ignitible concentrations of flammable gases or vapors are present continuously; or (2) in which ignitible concentrations of flammable gases or vapors are present for long periods of time.

3.2.10.2 Class I, Zone 1: A Class I, Zone 1 location is a location (1) in which ignitible concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or (2) in which ignitible concentrations of flammable gases or vapors may exist frequently because of repair

or maintenance operations or because of leakage; or (3) in which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitible concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or (4) that is adjacent to a Class I, Zone 0 location from which ignitible concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

3.2.10.3 Class I, Zone 2: A Class I, Zone 2 location is a location (1) in which ignitible concentrations of flammable gases or vapors are not likely to occur in normal operation and if they do occur will exist only for a short period; or (2) in which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors normally are confined within closed containers of closed systems from which they can escape, only as a result of accidental rupture or breakdown of the containers or system, or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or (3) in which ignitible concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as a result of failure or abnormal operation of the ventilation equipment; or (4) that is adjacent to a Class I, Zone 1 location, from which ignitible concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Note: Within this document, "Zone 0", "Zone 1", and "Zone 2" are understood to be preceded by "Class 1".

3.2.10.4 gas groups: For purposes of testing, approval, and area classification, various air mixtures (not oxygen enriched) are grouped as in 3.2.10.4.1 through 3.2.10.4.2.3 below.

3.2.10.4.1 Group I: A term used by IEC 79-10 to describe atmospheres containing firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines). Since this recommended practice does not apply to installations underground in mines, this term is not used further.

3.2.10.4.2 Group II: The group used to describe gases found aboveground and is subdivided into IIC, IIB, and IIA, as noted in 3.2.10.4.2.1 through 3.2.10.4.2.3 below, according to the nature of the gas or vapor, for protection techniques "d", "ia", "ib" [ia], and [ib], and, where applicable, "n" and "o".

3.2.10.4.2.1 Group IIA: Atmospheres containing acetone, ammonia, ethyl alcohol, gasoline, methane, propane, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode having either a maximum experimental safe gap (MESG) value greater than 0.90 mm (35 mils) or a minimum igniting current ratio (MIC ratio) greater than 0.80. (NFPA 497)

3.2.10.4.2.2 Group IIB: Atmospheres containing acetaldehyde, ethylene, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode having either a maximum experimental safe gap (MESG) value greater than 0.50 mm (20 mils) and less than or equal to 0.90 mm (35 mils) or a minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80. (NFPA 497)

3.2.10.4.2.3 Group IIC: Atmospheres containing acetylene, hydrogen, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a maximum experimental safe gap (MESG) value less than or equal to 0.50 mm (20 mils) or a minimum igniting current ratio (MIC ratio) less than 0.45. (NFPA 497)

3.2.10.5 hazardous (classified) location: A location where fire or explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dust, or ignitible fibers or flyings. Unless specifically indicated otherwise, locations containing combustible dust, ignitible fibers or flyings are outside the scope of this recommended practice.

3.2.10.6 unclassified location (non-hazardous location): A location not classified as Class I, Zone 0, Zone 1, or Zone 2.

3.2.11 Reserved for future use.

3.2.12 combustible liquid (Class II, IIIA, and IIIB Liquids): Any liquid that has a closed-cup flash point at or above 37.8°C (100°F), as determined by the test procedures and apparatus outlined in NFPA 30. Combustible Liquids are subdivided as follows:

3.2.12.1 Class II liquids—liquids having flash points at or above 37.8°C (100°F) and below 60°C (140°F).

3.2.12.2 Class IIIA liquids—liquids having flash points at or above 60°C (140°F) and below 93°C (200°F).

3.2.12.3 Class IIIB liquids—liquids having flash points at or above 93°C (200°F).

3.2.13 density of a gas or a vapor, relative: The density of a gas or a vapor relative to the density of air at the same pressure and at the same temperature (air is equal to 1.0). (IEC 79-10, Mod).

3.2.14 drilling areas: Those areas in which wells are being drilled, recompleted, or reworked for the purpose of exploring for or producing oil or gas. Wells meeting any of the conditions of the above are referred to as "drilling wells." The term "drilling wells" does not include wells on which wireline work is being performed through a lubricator or wells into which, or from which, pumping equipment is being installed or removed.

3.2.15 enclosed area (room, building, or space): A three-dimensional space enclosed by more than two-thirds (2/3) of the possible projected plane surface area and of sufficient size to allow the entry of personnel. For a typical building, this would require that more than two-thirds (2/3) of the walls, ceiling, and/or floor be present.

3.2.16 enclosure, electrical: The case or housing of electrical apparatus provided to prevent personnel from accidentally contacting energized parts and to protect the equipment from physical damage. Certain enclosures also serve to prevent electrical equipment from being a source of ignition of flammable mixtures outside the enclosure.

3.2.17 enclosure, explosionproof: An enclosure that is capable of withstanding an explosion of a specific gas or vapor within it and of preventing the subsequent ignition of a flammable gas or vapor that may surround it, and which operates at such an external temperature that a surrounding flammable gas or vapor will not be ignited.

3.2.18 enclosure, flameproof: An enclosure that will withstand an internal explosion of a flammable mixture that has penetrated into the interior, without suffering damage and without causing ignition, through any joints or structural openings in the enclosure, of an external explosive atmosphere consisting of one or more of the gases or vapors for which it is designed.

3.2.19 enclosure, purged: An enclosure or building supplied with clean air or an inert gas at sufficient flow and positive pressure to reduce the concentration of any flammable gases or vapors initially present to an acceptably safe level and to maintain this safe level by positive pressure with or with out continuous flow. For further information, see Standard for Purged and Pressurized Enclosures for Electrical Equipment, ANSI/NFPA 496.

3.2.20 explosive gas atmosphere: A mixture with air, under atmospheric conditions, of a flammable material in the form of gas or vapor in which, after ignition, combustion spreads throughout the unconsumed mixture. (IEV 426-02-03, Mod)

Note: Although a mixture that has a concentration above the upper explosive limit (UEL) is not an explosive gas atmosphere, it can readily become so and, in certain cases for area classification purposes, it is advisable to consider it as an explosive gas atmosphere.

3.2.20.1 flammable: Capable of igniting easily, burning intensely or spreading flame rapidly.

3.2.21 flammable (explosive) limits: The lower and upper percentages by volume of concentration of gas in a gas-air mixture that will form an ignitible mixture. (Reference NFPA 325).

3.2.22 flammable, highly volatile liquid: see "Highly Volatile Liquid."

3.2.23 flammable liquid (Class I liquid): Any liquid that has a closed-cup flash point below 37.8°C (100°F), as determined by the test procedures and apparatus specified in NFPA 30. Flammable (Class I) liquids are subdivided into Classes IA, IB, and IC. (Reference NFPA 30).

3.2.24 flash point: The minimum temperature of a liquid at which sufficient vapor is given off to form an ignitible mixture with air, near the surface of the liquid or within the vessel used, as determined by the test procedure and apparatus specified in NFPA 30.

3.2.25 floor area: The maximum area of any horizontal plane intersecting an enclosed area

3.2.26 fugitive emissions: Continuous flammable gas and vapor releases that are relatively small compared to releases due to equipment failures. These releases occur during normal operation of closed systems from components such as pump seals, valve packing and flange gaskets. (Reference Appendix B, API 4615, API 4589 and NFPA 30).

3.2.27 gases, heavier-than-air: Gases with a specific gravity greater than 1.0. See Section 7.2.2.

3.2.28 gases, lighter-than-air: Gases with a specific gravity less than 1.0. See Sections 5.4 and 7.2.2.

3.2.29 grades of release: There are three basic grades of release, as listed below in order of decreasing likelihood of the explosive gas atmosphere being present (IEC 79-10, Mod):

a. continuous grade;
b. primary grade;
c. secondary grade.

Note: A source of release may give rise to any one of these grades of release, or to a combination of more than one.

3.2.29.1 grade of release, continuous: A release that is continuous or is expected to occur for long periods.

3.2.29.2 grade of release, primary: A release that can be expected to occur periodically or occasionally during normal operation.

3.2.29.3 grade of release, secondary: A release that is not expected to occur in normal operation and if it does occur, is likely to do so only infrequently and for short periods.

3.2.30 high temperature device: A device whose maximum operating temperature exceeds 80 percent of the ignition temperature, expressed in degrees Celsius (°C), of the gas or vapor involved.

3.2.31 highly volatile liquid (HVL): A liquid whose vapor pressure exceeds 276 kPa (40 psia) at 37.8°C (100°F). See Section 5.3.

3.2.32 ignitible (flammable) mixture: A gas-air mixture that is capable of being ignited by an open flame, electric arc or spark, or device operating at or above the ignition temperature of the gas air mixture. See "Flammable (Explosive) Limits."

3.2.33 ignition (autoignition) temperature (AIT): The lowest temperature of a heated surface at which, under specified conditions, the ignition of a flammable substance in the form of a gas or vapor mixture with air will occur. (IEC 79-10, Mod)

Note: IEC 79-4 and IEC 79-4A standardize a method for the determination of this temperature. (IEV 426-02-01, Mod). To determine properties of specific flammable liquids, flammable gases and volatile solids, refer to ASTM E-659, *Test for Autoignition Temperature of Liquid Chemicals.* To obtain the autoignition temperature of specific flammable liquids, flammable gases, and volatile solids, refer to NFPA 497.

3.2.34 intrinsically safe system: An assembly of interconnected intrinsically safe apparatus, associated apparatus, and interconnecting cables in which those parts of the system that may be used in hazardous (classified) locations are intrinsically safe circuits. An intrinsically safe system may include more than one intrinsically safe circuit.

3.2.35 intrinsically safe circuit: A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under test conditions prescribed by UL 913.

3.2.36 intrinsically safe apparatus: Apparatus in which all the circuits are intrinsically safe.

3.2.37 location: Throughout this recommended practice, reference is made to areas, spaces, and locations. These terms should be considered interchangeable terms designating a three-dimensional space.

3.2.38 Maximum Experimental Safe Gap (MESG): The maximum gap of the joint between the two parts of the interior chamber of a test apparatus that, when the internal gas mixture is ignited and under specified conditions, prevents ignition of the external gas mixture by flame propagation through a 25 mm (984 mils) long joint, for all concentrations of the tested gas or vapor in air.

3.2.39 Minimum Ignition Current (MIC): The minimum current that, in a specified spark test apparatus and under specified conditions, is capable of igniting the most easily ignitible mixture.

3.2.40 Minimum Igniting Current ratio (MIC ratio): The ratio of the minimum current required from an inductive spark discharge to ignite the most easily ignitable mixture of a gas or vapor divided by the minimum current required from an inductive spark discharge to ignite methane under the same test conditions. (NFPA 497)

3.2.41 Minimum Ignition Energy (MIE): The minimum energy required from a capacitive spark discharge to ignite the most easily ignitable mixture of a gas or vapor. (NFPA 497)

3.2.42 mist, flammable: Droplets of flammable liquid, dispersed in air so as to form an explosive atmosphere. (IEC 79-10, Mod)

3.2.43 non-hazardous location: see 3.2.10.6 "Classification, unclassified location."

3.2.44 normal operation: The situation when the equipment is operating within its design parameters. (79-10, Mod)

3.2.45 petroleum refinery: A facility within which petroleum liquids or vapors are continuously processed at elevated temperatures and pressures to effect both chemical and physical changes.

3.2.46 pipeline transportation facility: A facility handling the delivery of flammable or combustible petroleum liquids or flammable gases; may include pump and compressor stations, storage facilities, manifold areas, valve sites, and pipeline right-of-way areas.

3.2.47 production areas: Those areas where flammable petroleum gas and volatile liquids are produced, processed (e.g., compressed), stored, transferred (e.g., pumped), or otherwise handled prior to entering the transportation facilities.

3.2.48 protected fired vessel: Any fired vessel that is provided with equipment (such as flame arresters, stack temperature shutdowns, forced draft burners with safety controls, and spark arresters) designed to eliminate the air intake and exhaust as sources of ignition.

3.2.49 release, source of: A point or location from which a flammable gas, vapor, or liquid may be released into the atmosphere such that an ignitible gas atmosphere could be formed. (IEV 426-03-06, Mod)

3.2.50 release rate: The quantity of flammable gas or vapor emitted per unit time from the source of release. (IEC 79-10, Mod)

3.2.51 space: see "Location."

3.2.52 unclassified location: see "Classification."

3.2.53 vapor pressure: The pressure exerted when a solid or liquid is in equilibrium with its own vapor. It is a function of the substance and of the temperature. The pres-

sure [measured in pounds per square inch absolute (kilopascals)] exerted by a volatile liquid as determined by ASTM D 323-82. (IEC 79-10, Mod)

3.2.54 vapor-tight barrier: A barrier that will not allow the passage of significant quantities of gas or vapor at atmospheric pressure.

3.2.55 ventilation: Movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors). (IEC 79-10, Mod)

3.2.56 ventilation, adequate: Ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapor-air or gas-air mixtures in concentrations above 25 percent of their lower flammable (explosive) limit, LFL (LEL). Reference also Section 6.3.2.

3.2.57 ventilation, inadequate: Ventilation that is less than adequate. See Section 6.3.3.

3.2.58 volatile flammable liquid: A flammable liquid whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 276 kPa (40 psia) at 37.8°C (100°F) whose temperature is above its flash point.

3.2.59 wireline work areas: Those areas in which wireline work is being performed on a well through a lubricator.

4 Basic Conditions for a Fire or Explosion

4.1 Three basic conditions must exist in order for a fire or explosion to occur as a result of an electrical installation:

a. A flammable gas or vapor must be present. In classifying a particular location, the likelihood of the presence of a flammable gas or vapor is a significant factor in determining the zone classification. The decision is based principally on whether the flammable mixture may be present (1) under normal conditions, or (2) only under abnormal conditions (including equipment breakdown).

b. The gas or vapor must be mixed with air or oxygen in the proportions and quantities required to produce a flammable or ignitible mixture. This condition is important in determining the limit or extent of the classified location. The quantity of the substance that might be liberated, its physical characteristics, the operating pressure, and the natural tendency of gases and vapors to disperse in the atmosphere should be considered.

c. The mixture must be ignited. When classifying locations, the potential source of ignition is understood to be an electrical installation operating at energy levels or at temperatures sufficient to cause ignition.

5 Flammable and Combustible Liquids, Gases, and Vapors

5.1 GENERAL

Substances handled by petroleum facilities include flammable and combustible liquids, flammable highly volatile liquids (HVLs), and flammable gases and vapors. When classifying locations for electrical installations, the appropriate gas Group(s) (IIA, IIB, or IIC) should be determined for all flammable liquids, gases, and vapors present.

5.2 FLAMMABLE AND COMBUSTIBLE LIQUIDS

5.2.1 General

Refer to NFPA 325 for properties of specific flammable liquids, flammable gases, and volatile solids. Flammable and combustible liquids vary in volatility and are defined in NFPA 30. Flammable (Class I) liquids, such as gasoline, are defined as any liquids having a closed-cup flash point below 37.8°C (100°F) and a vapor pressure not exceeding 276 kPa (40 psia) at 37.8°C (100°F). Combustible (Class II and Class III) liquids, such as kerosene and diesel fuel, are defined as liquids having a closed-cup flash point at or above 37.8°C (100°F). Class II liquids are combustible liquids having flash points at or above 37.8°C (100°F) and below 60°C (140°F). Class III liquids are combustible liquids having flash points at or above 60°C (140°F).

Note: Classes as used here to identify flammable and combustible liquids should not be confused with the classes in the National Electrical Code that identify specific types of flammable or explosive atmospheres. See Section 5.5 and definitions in Section 3.

5.2.2 Class I Liquids

5.2.2.1 Class I liquids usually are handled at temperatures above the liquids' flash point and, consequently, may produce a flammable atmosphere. Where released in appreciable quantities to the atmosphere, they may produce large volumes of vapor. This is particularly true for the more volatile Class I liquids. The less volatile Class I liquids release vapors more slowly at normal temperatures and are ignitible only near the surfaces of the liquids. At elevated temperatures, however, these heavier liquids give off large volumes of vapor that can spread. These vapors, even when evolved rapidly, have a natural tendency to disperse into the atmosphere and, thus, rapidly become diluted to concentrations below their lower flammable limit. This tendency is greatly accelerated by air movement.

5.2.2.2 The density of an atmosphere saturated with vapors of flammable liquids at ordinary atmospheric temperatures usually is heavier than air. However, when these vapors are diluted with sufficient air to create a flammable mixture, the density of the mixture approaches that of air.

5.2.3 Class II Liquids

5.2.3.1 With Class II liquids, the probability of an ignitible vapor-air mixture is low because the liquids typically are handled at temperatures below their flash point, where they do not produce sufficient vapors to form an ignitible mixture. When these liquids are heated above their flash point, additional vapors are generated, and the probability of ignition is increased.

5.2.3.2 The chance of ignition of vapors of Class II liquids is not as great as ignition of the vapors of Class I liquids. Their vapors normally do not travel as far as the vapors of Class I liquids. Normally, except near points of release, Class II liquids do not produce vapors of sufficient quantity to be considered for electrical classification purposes.

5.2.4 Class III Liquids

5.2.4.1 Class III liquids normally do not produce vapors of sufficient quantity to be considered for electrical classification purposes. Class III liquids will release vapor in the flammable range at their surfaces if heated above their flash points, but the extent of the classified location ordinarily will be very small and near the point of release.

5.2.5 Crude Oils

5.2.5.1 A specific classification for crude oil is not possible since crude oil is a mixture of hydrocarbons of widely varying composition. Some crude oils may include volatiles (e.g., butane, propane, or natural gasoline). However, crude oil usually is classified as a Class I flammable liquid, and its flash point generally is accepted as -6.7 to 32.2°C (20-90°F).

5.3 FLAMMABLE HIGHLY VOLATILE LIQUIDS

5.3.1 Highly volatile liquids (HVLs) include liquids such as butane, ethane, ethylene, propane, propylene, liquefied natural gas, natural gas liquids, and mixtures of such. Vapor pressures of these liquids exceed 276 kilopascals (40 psia) at 37.8°C (100°F).

5.3.2 Highly volatile liquids vaporize at low temperatures (have low flash points). When released to the atmosphere, these liquids vaporize—creating large volumes of cooled gases whose densities exceed that of air. HVLs should be treated very conservatively in considering the extent of the area affected, especially when released at or near ground level. Under such conditions, the heavy gases can travel along the ground for great distances if air currents do not assist dispersion. When HVLs are released at higher elevations, or are directed upward at substantial velocity, diffusion and dilution of the upper-air mixture are faster, and the distance from the point of release where LFL concentrations are present is less.

5.4 FLAMMABLE LIGHTER-THAN-AIR GASES

5.4.1 Petroleum facilities frequently handle lighter-than-air natural gases (methane or mixtures of methane and small quantities of low-molecular-weight hydrocarbons).

5.4.2 Lighter-than-air gases released from an opening often will disperse rapidly because of their relatively low density and usually will not affect as extensive an area as the vapors of flammable liquids or heavier-than-air gases. Lighter-than-air gases seldom produce large volumes of ignitible mixtures in open locations close to grade where most electrical installations are made; however, ignitible mixtures can accumulate inside enclosed spaces.

5.4.3 Hydrogen must be given special consideration because of its properties of wide explosive-mixture range, high flame-propagation velocity, low vapor density, low minimum-ignition-energy level, and relatively high ignition temperature [520°C (968°F)].

5.5 NATIONAL ELECTRICAL CODE GROUPING OF ATMOSPHERIC MIXTURES

5.5.1 Equipment must be selected, tested, and approved for the specific flammable material involved because maximum explosive pressures and other characteristics vary widely. For purposes of testing, approval, and area classification, various atmospheric mixtures (not oxygen enriched) are grouped in the National Electrical Code on the basis of their flammability characteristics. A partial listing follows; for a more complete listing refer to NFPA 497.

Group I is intended for use in describing atmospheres containing firedamp (a mixture of gases, composed mostly of methane, found underground, usually in mines. This recommended practice does not apply to installations underground in mines. Group II is subdivided into IIA, IIB, and IIC.

The gas and vapor sub-division as described above is based on the maximum experimental safe gap (MESG), minimum igniting current (MIC), or both. Test equipment for determining the MESG is described in *Construction and Verification Tests of Flameproof Enclosures of Electrical Apparatus*, IEC 79-1A (1975-Amendment No. 1, 1993) and UL Technical Report No. 58 (1993). The test equipment for determining MIC is described in *Spark-test apparatus for intrinsically-safe circuits*, IEC 79-3 (1990). The classification of gases or vapors according to their maximum experimental safe gaps and minimum igniting currents is described in *Classification of mixtures of gases or vapours with air according to their maximum experimental safe gaps and minimum igniting currents*, IEC 79-12 (1978).

It is necessary that the meanings of the different equipment markings and Group II classifications be carefully observed to avoid confusion with Class I, Divisions 1 and 2, Groups A, B, C, and D.

(a) Group IIC. Atmospheres containing acetylene, hydrogen, or gases or vapors of equivalent hazard.

Note: Group IIC is equivalent to a combination of Class I, Group A and Class I, Group B, as described in NEC Sections 500-3(a)(1) and (a)(2).

(b) Group IIB. Atmospheres containing acetaldehyde, ethylene, or gases or vapors of equivalent hazard.

Note: Group IIB is equivalent to Class I, Group C, as described in NEC Section 500-3(a)(3).

(c) Group IIA. Atmospheres containing acetone, ammonia, ethyl alcohol, methane, propane, or gases or vapors of equivalent hazard.

Note: Group IIA is equivalent to Class I, Group D as described in NEC Section 500-3(a)(4).

5.5.2 The explosive characteristics of mixtures of gases or vapors and air vary with the specific material(s) involved. For Class I locations (Groups IIA, IIB, and IIC), the classification involves determinations of maximum explosion pressure, maximum safe clearance between parts of a clamped joint in an enclosure, and other characteristics of the atmospheric mixture.

5.5.3 Most petroleum products are placed in Group IIA. However, ethylene production, catalytic reforming, ammonia synthesis, and other processes may involve other groups, particularly Group IIB.

5.5.4 Locations with rechargeable batteries that can discharge hydrogen to the atmosphere should be reviewed for possible Group IIC classification. See Section 8.2.6.

5.5.5 In mixtures of hydrogen sulfide and natural gas, it is recommended that the mixture be considered Group IIA if the hydrogen sulfide constitutes less than 25 percent of the mixture (by volume).

5.5.6 Table 1 presents an approximate comparison of the NEC "Division" Grouping with the IEC "Zone" Grouping (ISA S12.0.01):

Table 1—Approximate Comparison of IEC Apparatus and NEC Gas Groups

IEC Group Designation NEC Article 505 Group Designation	NEC Article 500 Group Designation	Typical Gas
IIC	A	Acetylene
(IIB + H_2)*	B	Hydrogen
IIB	C	Ethylene
IIA	D	Propane

*Note: (IIB + H_2) is not an IEC/NEC Gas Group. As Type of Protection flameproof 'd' does not permit the use of flange joint apparatus in atmospheres containing acetylene, this designation is commonly used for such apparatus to designate that it can be used in Group IIB atmospheres and hydrogen atmospheres. This is generally representative of IIC atmospheres that do not include acetylene.

6 Classification Criteria

6.1 GENERAL

6.1.1 The decision to classify a location is based on the probability that flammable gases or vapors may be present. Possible sources of release include vents, flanges, control valves, drains, pump and compressor seals, fittings, and floating roof seals. It is noted that the occurrence of flammable material liberation from some of the above apparatus is so infrequent and at such a small rate, that it is not necessary to consider it as a source or to classify adequately ventilated nonenclosed areas containing such apparatus. Factors described in Sections 5 through 14 should be used in that determination. Having decided that a location should be classified, and having designated the gas or vapor as Group IIA, IIB, or IIC, the next step is to designate the location as either Zone 0, Zone 1, or Zone 2. This latter step must consider the probability of whether a flammable gas or vapor release is likely to occur in sufficient quantities to be ignitible during normal operations, or only as a result of an unusual occurrence or abnormal condition.

6.1.2 Mists may form or be present at the same time as flammable vapors. This may affect the way flammable material disperses and the extent of any hazardous areas. The strict application of area classification for gases and vapors may not be appropriate because the flammability characteristics of mists are not always predictable. Although it can be difficult to decide upon the type and extent of zones, the criteria applicable to gases and vapors will, in most cases, give a safe result. However, special consideration should always be given to the danger of ignition of flammable mists. (IEC 79-10, Mod)

6.2 SOURCES OF RELEASE (IEC 79-10, MOD)

6.2.1 The basic elements for establishing the hazardous zone types are the identification of the source of release and the determination of the grade of release.

6.2.2 Since an explosive-gas atmosphere can exist only if a flammable gas or vapor is present with air, it is necessary to decide if any of these flammable materials can exist in the area concerned. Generally speaking, such gases and vapors (and flammable liquids and solids that may give rise to them) are contained within equipment and piping, which may or may not be totally enclosed. It is necessary to identify where a release of flammables could occur from such equipment or piping.

6.2.3 Each item of process equipment should be considered as a potential source of release of flammable material. If the item cannot contain flammable material, it clearly will not necessitate a hazardous (classified) area around it. The same will apply if the item contains a flammable material but is not likely to release it into the atmosphere; see Section 6.5.9.

If it is established that flammable material may be released into the atmosphere, it first is necessary to determine the grade of release in accordance with the definitions, by establishing the likely frequency and duration of the release. It should be recognized that the opening of parts of enclosed process systems (for example, during filter changing) also should be considered as sources of release when developing the area classification. By means of this procedure, each release will be graded either "continuous," "primary" or "secondary."

Having established the grade of the release, it then is necessary to determine the release rate and other factors (including ventilation) that may influence the type and extent of the zone.

6.3 ZONE DESIGNATION (IEC 79-10, MOD)

The likelihood of the presence of an explosive gas atmosphere, and hence the zone designation, depends mainly on the grade of release and the ventilation.

Note: A continuous grade of release normally leads to a Class I, Zone 0 designation; a primary grade to a Class I, Zone 1 designation; and a secondary grade to a Class I, Zone 2 designation.

6.4 EXTENT OF ZONE (IEC 79-10, MOD)

6.4.1 Where the source of release is situated outside an area or in an adjoining area, the penetration of a significant quantity of flammable gas or vapor into the area can be prevented by suitable means such as:

a. physical barriers;
b. maintaining a static overpressure in the area relative to the adjacent hazardous areas, so preventing the ingress of the hazardous atmosphere; and
c. purging the area with a significant flow of air, so ensuring that the air escapes from all openings where the hazardous gas or vapor may enter.

6.4.2 The extent of the zone is mainly affected by the following chemical and physical parameters, some of which are intrinsic properties of the flammable material; others are specific to the process. For simplicity, the effect of each parameter listed below assumes that the other parameters remain unchanged.

6.4.2.1 Release Rate of Gas or Vapor

The greater the release rate, the larger the extent of the classified location. The release rate depends itself on other parameters, namely:

a. Geometry of the source of release

This is related to the physical characteristics of the source of release—for example, an open surface.

b. Release velocity

For a given source of release, the release rate increases with the release velocity. In the case of a product contained within process equipment, the release velocity is related to the process pressure and the geometry of the source of release. The size of a cloud of flammable gas or vapor is determined by the rate of flammable vapor release and the rate of dispersion. Gas and vapor flowing from a leak at high velocity will develop a cone-shaped jet that will entrain air and will be self-diluting. The extent of the explosive atmosphere will be almost independent of wind velocity. If the release is at low velocity or if its velocity is destroyed by impingement on a solid object, it will be carried by the wind and its dilution and extent will depend on wind velocity.

c. Concentration

The release rate increases with the concentration of flammable vapor or gas in the released mixture.

d. Volatility of a flammable liquid

The volatility of a flammable liquid is related principally to the vapor pressure and to the heat of vaporization. If the vapor pressure is not known, the boiling point and flashpoint can be used as a guide.

An explosive atmosphere cannot exist if the flashpoint is above the relevant maximum temperature of the flammable liquid. The lower the flashpoint, the greater may be the extent of the zone. If a flammable material is released in a way that forms a mist (for example, by spraying) an explosive atmosphere may be formed below the flashpoint of the material.

Note 1: Flashpoints of flammable liquids are not precise physical quantities, particularly where mixtures are involved.

Note 2: Some liquids (for example, certain halogenated hydrocarbons) do not possess a flashpoint although they are capable of producing an explosive gas atmosphere. In these cases, the equilibrium liquid temperature that corresponds to the saturated concentration at the lower explosive limit should be compared with the relevant maximum liquid temperature.

e. Liquid temperature

The vapor pressure increases with temperature, thus increasing the release rate due to evaporation.

Note: The temperature of the liquid after it has been released may increase—for example, by a hot surface or by a high ambient temperature.

6.4.2.2 Lower Explosive Limit (LEL)

For a given release volume, the lower the LEL the greater will be the extent of the classified location.

6.4.2.3 Ventilation

With increased ventilation, the extent of the classified location will be reduced. Obstacles that impede the ventilation may increase the extent of the classified location. On the other hand, some obstacles (for example, dikes, walls, and ceilings) may limit the extent.

6.4.2.4 Relative Density of the Gas or Vapor When it is Released

If the gas or vapor is significantly lighter than air, it will tend to move upwards. If significantly heavier, it will tend to

accumulate at ground level. The horizontal extent of the classified location at ground level will increase with increasing relative density, and the vertical extent above the source will increase with decreasing relative density.

Note 1: For practical applications, a gas or vapor that has a relative density below 0.8 is regarded as being lighter than air. If the relative density is above 1.2, it is regarded as being heavier than air. Between these values, both of these possibilities should be considered.

Note 2: Experience has shown that ammonia is hard to ignite, and a gas release will dissipate rapidly in the open air, so any explosive gas atmosphere will be of negligible extent.

Note 3: Consideration should always be given to the possibility that a gas that is heavier than air may flow into areas below ground level (for example, pits and depressions) and that a gas that is lighter than air may be retained at high level (for example, in a roof space).

6.4.2.5 Other Parameters to be Considered

a. Climatic conditions.
b. Topography.

6.4.2.6 Effects of Parameters

Some ways in which the above parameters affect the vapor or gas release-rate, and hence the extent of the classified locations, are given below.

a. Source of release: open surface of liquid

In most cases, the liquid temperature will be below the boiling point and the vapor release rate will depend principally on the following parameters:

1. liquid temperature;
2. vapor pressure of the liquid at its surface temperature; and
3. dimensions of the evaporation surface.

b. Source of release: virtually instantaneous evaporation of a liquid (for example, from a jet or spray)

Since the discharged liquid vaporizes virtually instantaneously, the vapor release rate is equal to the liquid flow rate, and liquid flow rate depends on the following parameters:

1. liquid pressure; and
2. geometry of the source of release.

Where the liquid is not instantaneously vaporized, the situation is complex because droplets, liquid jets and pools may create separate sources of release.

c. Source of release: leakage of a gas mixture

The gas release rate is affected by the following parameters:

1. pressure within the equipment that contains the gas;
2. geometry of the source of release; and
3. concentration of the flammable gas in the released mixture.

6.5 NATIONAL ELECTRICAL CODE CRITERIA

6.5.1 NEC Classifications

The following basic definitions concerning the classifications of areas are the same as those contained in Article 505 of NFPA 70, the National Electrical Code, except for a few editorial changes for clarity and deletion of some subject matter not relevant to petroleum operations.

6.5.1.1 Class I Locations

Class I locations are those in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations include the following:

6.5.1.1.1 Class I, Zone 0. A Class I, Zone 0 location is a location (1) in which ignitible concentrations of flammable gases or vapors are present continuously; or (2) in which ignitible concentrations of flammable gases or vapors are present for long periods of time.

Note: As a further guide in determining when flammable gases or vapors are present continuously or for long periods of time, also refer to Section 6.5.8; Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous Areas, IEC 79-10; and Area Classification Code for Petroleum Installations, Model Code, Part 15, Institute of Petroleum; and Electrical Apparatus for Explosive Gas Atmospheres, Classifications of Hazardous (Classified) Locations, ISA S12.24.01.

6.5.1.1.1.1 This classification usually includes locations inside vented tanks or vessels containing volatile flammable liquids; between the inner and outer roof sections of a floating roof tank containing volatile flammable liquids; inside open vessels, tanks and pits containing volatile flammable liquids; the interior of an exhaust duct that is used to vent ignitible concentrations of gases or vapors; and inside inadequately ventilated enclosures containing normally venting instruments utilizing or analyzing flammable fluids and venting to the inside of the enclosures.

6.5.1.1.2 Class I, Zone 1. A Class I, Zone 1 location is a location (1) in which ignitible concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or (2) in which ignitible concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitible concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or (4) that is adjacent to a Class I, Zone 0 location from which ignitible concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

Note 1: Normal operations is considered the situation when plant equipment is operating within its design parameters. Minor releases of flammable material may be part of normal operations. Minor releases include the releases from mechanical packings on pumps. Failures that involve repair or shutdown (such as the breakdown of pump seals and flange gaskets, and spillage caused by accidents) are not considered normal operation.

Note 2: Failures (such as the breakdown of pump seals, flange gaskets or spillages caused by accidents) that involve urgent repair or shut-down are not considered to be part of normal operation.

6.5.1.1.2.1 This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interiors of refrigerators and freezers in which volatile flammable materials are stored in the open, lightly stoppered, or easily ruptured containers; and other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operation, but not classified Zone 0.

6.5.1.1.3 Class I, Zone 2. A Class I, Zone 2 location is a location (1) in which ignitible concentrations of flammable gases or vapors are not likely to occur in normal operation and if they do occur will exist only for a short period; or (2) in which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used, but in which the liquids, gases, or vapors normally are confined within closed containers of closed systems from which they can escape, only as a result of accidental rupture or breakdown of the containers or system, or as the result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or (3) in which ignitible concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as a result of failure or abnormal operation of the ventilation equipment; or (4) that is adjacent to a Class I, Zone 1 location, from which ignitible concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

6.5.1.1.3.1 The Zone 2 classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but that would become hazardous only in case of an accident or of some unusual operating condition.

6.5.2 Class I, Zone 0 Considerations

6.5.2.1 Zone 0 locations include areas that are likely to have ignitible concentrations of flammable gases or vapors present continuously or for long periods of time. For instance, the continuous presence of flammable gases inside a tank storing flammable fluids is normal and requires a Zone 0 classification.

6.5.3 Class I, Zone 1 Considerations

6.5.3.1 Zone 1 locations include areas that are likely to have ignitible concentrations of flammable gases or vapors present under normal conditions. For instance, the presence of flammable gases in the immediate vicinity of an atmospheric vent from a Zone 1 area, such as the roof vent depicted by Figure 16, is normal and requires a Zone 1 classification. However, "normal" does not necessarily mean the situation that prevails when everything is working properly. For instance, a process might be so sensitive to control that relief valves frequently open, which could be considered normal. If these valves release flammable liquids or gases to the atmosphere, the location adjacent to the point of release should be classified Zone 1. However, if the operation of the relief valves occurs infrequently under usual conditions, it is not to be considered normal. Normal conditions in this context also cover frequent routine events. For example, opening a scraper barrel for inserting or removing a scraper is a normal condition.

6.5.3.2 There may be cases in which frequent maintenance and repair are necessary. When these cases are viewed as normal, and if significant quantities of flammable liquids or gases are released as a result of the maintenance and repair, the location should be classified Zone 1. However, if the maintenance and repairs are required infrequently, the work is to be considered abnormal.

6.5.3.3 The Zone 1 classification also applies to the "transition zone" that normally exists between a Zone 0 location and a Zone 2 location. Obviously, flammable gases or vapors cannot be present on one side of an imaginary line and never be present on the opposite side. There should be a Zone 1 "transition zone" surrounding locations where flammable gases or vapors may be present continuously or for long periods of time. A vaportight barrier can be used, however, to prevent the gas or vapor from spreading. In such cases there would not be a transition zone and the other side of the barrier could be unclassified. Also, as discussed in Paragraph 6.5.1.1.3, adequate positive-pressure ventilation from a source of clean air can be used to eliminate the transition zone if effective safeguards against ventilation failure are provided.

6.5.3.4 When an enclosed area is classified Zone 0 "to the extent of the enclosed area", a Zone 1 transition zone must be included adjacent to all non-vaportight walls and other openings (e.g., hatches, doors and windows). If no specific transition zone is recommended by Sections 8 through 14 (as applicable), the Zone 1 area should extend as follows:

a. in the case of a Zone 0 area surrounding a specific item of equipment, the same distance from the Zone 0—Zone 1 boundary as the Zone 0 area extends from the specific equipment in question, or

b. in the case of an enclosed area classified Zone 0 to the extent of the enclosed area, three meters (10 feet) from the non-vaportight wall or opening.

6.5.4 Class I, Zone 2 Considerations

6.5.4.1 Zone 2 locations are likely to have flammable gases or vapors present only under abnormal conditions. As an example, consider an adequately ventilated location containing a process pump with a mechanical shaft seal that releases flammable gases or vapors only under abnormal conditions. In this case, there is no Zone 1 classification. To release gases or vapors, the seal would have to leak, which would be abnormal. Thus, the area surrounding the pump is classified as Zone 2.

6.5.4.2 Petroleum handling equipment does not fail frequently. Furthermore, the NEC requirements for electrical installations in Zone 2 locations allow that a source of ignition may occur in the event of an electrical equipment failure. This also does not happen frequently. For example, assume that the electrical and petroleum handling equipment each fail at the rate of once every 8,000 hours (once per year). The probability that both types of equipment will fail during the same hour is only one in 64 million. These assumed failure rates are deliberately high and the failures usually would occur during a time interval shorter than one hour. On a realistic basis, the probability of simultaneous failure is very remote; therefore, this consideration often justifies a Zone 2 (versus Zone 1) classification.

6.5.4.3 The Zone 2 classification also applies to the "transition zone" that normally exists between a Zone 1 location and an unclassified location. Obviously, flammable gases or vapors cannot be present on one side of an imaginary line and never be present on the opposite side. There should be a "transition zone" where flammable gases or vapors may be present under abnormal conditions. These abnormal conditions might be, for example, unfavorable air currents or an abnormally large release of flammable material. A vaportight barrier can be used, however, to prevent the gas or vapor from spreading. In such cases there would not be a transition zone and the other side of the barrier would be unclassified. Also, as discussed in Paragraph 6.5.1.1.3, adequate positive-pressure ventilation from a source of clean air can be used to eliminate the transition zone if effective safeguards against ventilation failure are provided.

6.5.4.4 When a building (or similar enclosed area) is classified Zone 1 "to the extent of the building" due to specific oil or gas handling equipment enclosed by the building, a Zone 2 transition zone must be included adjacent to all non-vaportight walls and other openings (e.g., doors and windows). If no specific transition zone is recommended by Sections 8 through 14 (as applicable), the Zone 2 area should extend as follows: 1) in the case of a Zone 1 area surrounding a specific item of equipment, the same distance from the Zone 1—Zone 2 boundary as the Zone 1 area extends from the specific equipment in question, or 2) in the case of a building (or similar enclosed area) classified Zone 1 to the extent of the building, three meters (10 feet) from the non-vaportight wall or opening.

6.5.4.5 When a building (or similar enclosed area) is classified Zone 2 "to the extent of the building" due to specific oil or gas handling equipment enclosed by the building, it is not necessary to extend the Zone 2 area beyond the building due to non-vaportight walls or other openings (e.g., doors and windows) except when specific equipment inside the building requires classification for distances beyond the openings. However, since these openings occasionally may provide communication for flammable gases or vapors, for enhanced safety it generally is recommended that arcing or high temperature electrical equipment not be installed immediately adjacent to such openings.

6.5.5 Vent Openings

Certain openings are designed specifically to vent or exhaust potentially flammable gases or vapors from buildings (or similar enclosed areas)—e.g., ridge vents and forced ventilation system exhausts. Such openings in buildings should be considered as vents and classified accordingly. Where such openings are from a Class I, Zone 0 location, this requires a Class I, Zone 0 classification (Zone 0 for 1.5 meters (five feet) past the openings unless otherwise specified in Section 8 through 14) surrounded by an adjacent Zone 1 transition zone unless otherwise specified in Sections 8 through 14, as applicable. Where such openings are from a Class I, Zone 1 location, this requires a Class I, Zone 1 classification (Zone 1 for 1.5 meters (five feet) past the openings unless otherwise specified in Section 8 through 14) surrounded by an adjacent Zone 2 transition zone unless otherwise specified in Sections 8 through 14, as applicable. The area outside such openings in buildings that are classified Zone 2 should be considered Zone 2 for 1.5 meters (five feet) past the openings unless otherwise specified in Section 8 through 14, as applicable.

6.5.5.1 Consider the case of a nonenclosed source that releases flammable gas or vapor during normal operations. The classified area around the source normally would appear as a Zone 1 concentric circle around the source, surrounded by a concentric Zone 2 circle. The Zone 2 area is the "transition zone". In some cases, the classified area around the source would appear as a Zone 0 concentric circle around the source, surrounded by concentric Zone 1 and Zone 2 circles.

6.5.6 Dual Classification

A Class I, Zone 2 location is allowed to abut, but not overlap, a Class I, Division 2 location. A Class I, Zone 0 or Zone 1 location is not allowed to abut a Class I, Division 1 or Division 2 location.

6.5.7 Classification Restrictions

A location may be classified in accordance with either the Zone or the Division concept provided all of the space that is

classified because of a single source of release is classified using either the Zone or the Division concept, but not both.

6.5.8 Relationship Between Grade of Release and Zone Classification

6.5.8.1 Although many guidelines relate the percent of time a location contains an ignitible concentration to the Zone classification, certain locations should be classified Zone 1 even though they seldom (timewise) contain an ignitible concentration. A room designated to spray items with flammable paint is one example of such a location. This room must be designated Zone 1—whether one paints once a day or once a month. The room's designated use dictates that an ignitible mixture will be present under normal conditions. That is, it is normal to have an ignitible mixture in the room when it is used for its designated purpose—without equipment failure. In the petroleum industry, an example of a location that should be considered Zone 1 is the space adjacent to the cover of a ball or pig launching or receiving installation. Although this location may seldom contain ignitible concentrations of gas, one should anticipate ignitible mixtures when the cover is opened to remove or insert a ball or pig—normal conditions for use of the equipment.

6.5.8.2 How frequently a flammable material may be present is applicable, however, to one of the NEC conditions that dictate a Zone 1 classification: "(2) in which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage."

Although there is no firm rule relating the time that flammable mixtures occur with Zone 0, Zonel, Zone 2, and unclassified locations, many (e.g., Section 1.5.5. of IP 15) use the following rule-of-thumb to relate grade of release to the presence of flammable mixtures as shown in Table 2.

Table 2—Showing the Relationship Between Grade of Release and the Presence of Flammable Mixtures

Grade of Release	Flammable Mixture Present
Continuous	1000 or more hours/year
Primary	10 < hours/ year < 1000
Secondary	less than 10 hours/year

6.5.8.3 Continuous grades of release normally lead to a Zone 0 classification. Primary grades of release normally lead to a Zone 1 classification. Secondary grades of release normally lead to a Zone 2 classification. However, it should be noted that the terms "Grade of Release" and "Zone" arenot synonymous. Although continuous, primary, and secondary grade releases normally will result in Zones 0, 1, and 2 classifications, respectively, this may not always be true. For example, poor ventilation may result in a more stringent classification while, with high ventilation provisions, the converse will be true. Also some sources may be considered to have a dual grade of release with a small continuous or primary grade and a larger secondary grade.

Although there is no firm rule relating the time that flammable mixtures occur with Zone 0, Zone 1, Zone 2, and unclassified locations, many use the rule-of-thumb shown in Table 3.

Table 3—Showing the Typical Relationship Between Zone Classification and the Presence of Flammable Mixtures

Zone	Flammable Mixture Present
0	1000 or more hours / year (10%)
1	10 < hours/year < 1000 (0.1% - 10%)
2	1 < hour / year < 10 (0.01% - 0.1%)
unclassified	Less than 1 hour/year (0.01%)

Note: The percentages shown in parentheses represent the approximate percentages of time (based on a year—8,760 hours, rounded to 10,000) when flammable mixtures are present.

6.5.9 Unclassified Locations

6.5.9.1 Experience has shown that certain locations may be unclassified regardless of the ventilation rate since the occurrence of flammable gas or vapor liberation from some apparatus is so infrequent. Examples of such locations include the following:

6.5.9.1.1 Locations where flammable substances are contained in:

a. all-welded closed piping systems without valves, flanges or similar devices, or

b. continuous metallic tubing without valves, fittings, flanges, or similar devices.

6.5.9.1.2 Locations where flammable liquids, gases or vapors are transported or stored in certain containers or vessels (Refer to NFPA recommendations and Department of Transportation, DOT, regulations specifying containers for flammable liquids and gases).

6.5.9.2 Adequately ventilated locations surrounding equipment that has continuous flame sources (e.g., unprotected fired vessels and flare tips) need not be classified solely by reason of the fuel gas being considered as a source of release.

Note 1: It may be prudent to classify portions of these locations. For example, electrical equipment may be exposed to flammable gas during a purge cycle of a fired heater or furnace.

Note 2: The lack of classification around unprotected fired vessels and flare tips does not imply the safe placement of fired vessels and flare tips in the proximity to other sources of release because unprotected fired vessels and flare tips are themselves sources of ignition. The decision of whether or not it is safe to install the unprotected fired vessel or flare tip at the location is outside the scope of this document.

6.5.9.3 The practice of not classifying locations where non-electrical ignition sources (e.g., the open flame of an unprotected fired vessel or flare tip) exist has been utilized in previous issues of RP 500. It is recommended that the application of this practice be limited to unprotected fired vessels or flare tips and that the resulting unclassified locations be restricted to their immediate vicinity. Electrical equipment located in these unclassified locations typically is de-energized for the majority of the time that the flame source is not present.

Note: Although from a practical view, when an open flame is present, a spark from electrical equipment in the immediate area of the flame would not likely be the initiator of combustion, the location of sources of ignition is not a criteria for the classification of locations. Classification is, by definition, based on the likelihood of the presence of flammable mixtures. It is not the intent of this document to recommend the creation of an unclassified location in which one can locate general purpose electrical devices that are not directly associated with the combustion or ignition systems of unprotected fired vessels or flare tips.

6.5.9.4 Other locations that contain hydrocarbon handling apparatus may be unclassified. See Sections 8 through 14, as applicable.

Note: The examples listed in Sections 8 through 14 consider only the specific equipment discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.

6.6 VENTILATION

6.6.1 General

6.6.1.1 The decision to classify a location as Zone 0, Zone 1, Zone 2, or unclassified, depends in part on the degree of ventilation of the location.

Gas or vapor released into the atmosphere can be diluted by dispersion or diffusion into the air until its concentration is below the lower explosion limit. Ventilation, i.e., air movement leading to replacement of the atmosphere in a (hypothetical) volume around the source of release by fresh air, will promote dispersion. Suitable ventilation rates can also avoid persistence of an explosive gas atmosphere, thus influencing the type of zone. (IEC 79-10, Mod)

6.6.1.2 Providing ventilation to allow the reclassification of an enclosed area from classified to unclassified is not allowed in enclosed areas containing devices handling hydrocarbons. Equipment as described by Section 6.2.4.1 and hydrocarbon-fueled prime movers (Reference Section 8.2.5 and NFPA 37) are excluded.

6.6.1.3 Fixed open louvers, open grating, and the like, may be considered the same as open floors, roofs, or walls. Adjustable louvers that can be closed should be considered the same as closed floors, roofs, or walls for ventilation purposes. Adjustable louvers that are closed only during abnormal conditions (such as during a fire or fire suppressant release) and are closed only automatically can be considered the same as open floors, roofs, or walls for ventilation purposes. It is realized that floors, roofs, and walls will contain structural members, columns, and the like that are not equivalent to open grating and louvers; when such obstructions constitute less than 15 percent of the total area, they may be disregarded for ventilation degree determination.

6.6.1.4 In general, a naturally ventilated location (building, room, or space) should be substantially open and free from obstruction to the natural passage of air through it, vertically and horizontally. Such locations may be roofed or partially closed on the sides, or both.

6.6.1.5 The calculation methods given in Appendix F may be utilized to verify adequate ventilation as defined by 6.6.2.1.

6.6.2 Adequate Ventilation

6.6.2.1 Adequate ventilation is defined as ventilation (natural or artificial) that is sufficient to prevent the accumulation of significant quantities of vapor-air or gas-air mixtures in concentration above 25 percent of their lower flammable (explosive) limit, LFL (LEL). Refer to NFPA 30 for additional details.

6.6.2.2 The source of air used for ventilation should not be from an area classified as Zone 0 or Zone 1. If practical, the source of air should be from an unclassified area.

6.6.2.3 In determining adequate ventilation, the gas or vapor concentration can be considered to be homogeneous, although it is recognized that there may be small "pockets" of higher concentrations near sources of release.

6.6.2.4 Methods of Achieving Adequate Ventilation

6.6.2.4.1 General

Several methods of achieving adequate ventilation are listed below. The list is not intended to be all-inclusive. Any method utilized is required to satisfy both (a) and (b) below, as applicable.

a. For flammable liquids with heavier-than-air vapors, ventilation must be arranged to ventilate all areas (particularly floor areas) where flammable vapors might collect; and

b. For lighter-than-air gases, roof or wall openings must be arranged to ventilate all areas (particularly ceiling areas) where gases might collect.

Note: Reference Section 7.2.2.

6.6.2.4.2 Enclosed areas (rooms, buildings, or spaces) that are provided at least 0.028 cubic meters (1.0 cubic foot) of air volume flow per minute per square foot of floor area, but at least six (6) air changes per hour, can be considered as adequately ventilated. This ventilation rate can be accomplished by either natural or mechanical means.

6.6.2.4.3 "Floor area" is the maximum area of any horizontal plane intersecting an enclosed area.

6.6.2.4.4 Recirculation of inside air is permitted if

a. the recirculated air is monitored continuously with a gas detection system meeting the requirements of Section 6.5.2a through i, and

b. the gas detection system is designed to automatically stop recirculation, provide an alarm (audible or visual, or both, as most appropriate for the area), and provide exhaust (at a minimum rate as described in Par. 6.6.2.4.2) to the outside if vapor-air mixtures in concentration over 20 percent of their lower flammable limit (LFL) are detected.

Note: Sufficient dilution air must be added to the space in question to ensure that the concentration of flammable gas or vapor is maintained below 25 percent of the lower flammable limit (LFL) for all but abnormal conditions.

6.6.2.4.5 For naturally ventilated enclosed areas (e.g., buildings), air flow due to thermal forces (stack effect) provides adequate ventilation if the inlet and outlet ventilation openings are properly sized and located. When determining adequate ventilation for enclosed areas using the mathematical analysis below, a safety factor of two should be used, which increases the minimum calculated air flow rate required to 12 air changes per hour. The minimum area for inlet and outlet openings in buildings to obtain a complete change of air each five minutes (12 air changes per hour) can be calculated from the following equations (Equation 1 and Equation 2) if there is no significant building internal resistance, and the inlet and outlet openings are vertically separated and on opposite walls. It is recommended that this method of calculating adequate ventilation be limited to enclosed areas (e.g., buildings) of approximately 28.3 cubic meters (1,000 cubic feet) or less.

6.6.2.4.6 Provisions need to be made for the introduction of air in a manner to properly distribute ventilation; that is, air should not be permitted to flow directly from the air inlet to the air outlet (short-circuited) without removing air previously within the enclosed area, or from the air outlet back into the air inlet.

Note: The specific equations below will determine the minimum area for inlet and outlet openings to provide a complete change of air each five minutes as recommended above. If a different time to exchange the inside air is desired, Equation 1 can be adjusted in an inverse linear manner; for example openings half as large would be required for a complete change of air each ten minutes. As T_i approaches T_o the stack effect is reduced.

$$A = \frac{V}{1200\sqrt{h(T_i - T_o)/T_i}} \qquad (1)$$

Where:

A = Free area of inlet (or outlet) opening(s), in square feet (includes a 50 percent effectiveness factor)

V = Volume of building to be ventilated, in cubic feet

h = See Equation 2

T_i = Temperature of indoor air, in degrees Rankine (degrees Fahrenheit plus 460)

T_o = Temperature of outdoor air, in degrees Rankine

Note 1: Equation 1 was derived from the 1985 ASHRAE Handbook of Fundamentals, Chapter 22, using Equations (5) and (10), assuming an air change every five minutes. Reference the above Handbook, Chapter 22, for additional information on naturally ventilated buildings. The derivations of Equations 1 and 2 are based on English units and conversions to SI units have not been made.

Note 2: Equation 1 applies when $T_i > T_o$. If $T_i < T_o$, replace T_i with T_o and replace T_o with T_i.

Note 3: The free area (A) determined in Equation 1 assumes that the free area of the inlet is equal to the free area of the outlet. If the areas are not equal, use the smaller of the two areas and refer to Figure 7, Chapter 22, of the 1985 ASHRAE Handbook of Fundamentals, reproduced below as Figure 1. The area of the openings (A) as determined from Equation 1 can be reduced by the same percentage as the "increase in percent" obtained from Figure 1.

$$h = \frac{H}{1 + [(A_1/A_2)^2(T_i/T_o)]} \qquad (2)$$

Where:

h = Height from the center of the louver opening to the Neutral Pressure Level (NPL), in feet. The NPL is the point on the vertical surface of a building where the interior and exterior pressures are equal.

A_1 = Free area of lower opening, in square feet

A_2 = Free area of upper opening, in square feet

H = Vertical distance (center-to-center) between A_1 and A_2, in feet

Note: Equation 2 applies when $T_i > T_o$. If $T_i < T_o$, the ratio T_i/T_o should be inverted.

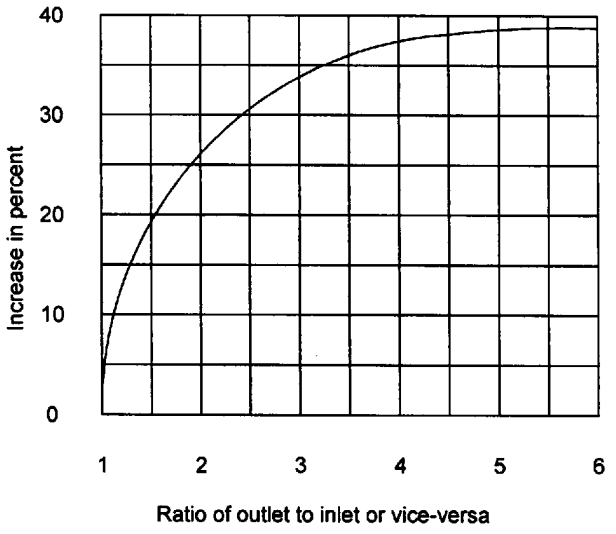


Figure 1—Increase in Flow Caused by Excess of One Opening Over Another (See Section 6.6.2.4.6)

A sample calculation for determining the minimum number of louvers required for adequate ventilation in a building (using Equations 1 and 2) is given in Appendix A.

6.6.2.4.7 Buildings or other enclosed or partially enclosed areas are considered adequately ventilated because of their construction characteristics if they comply with both 6.3.2.4.1 and one of the following:

a. A building or area having a roof or ceiling with walls comprising 50 percent or less vertical wall area than the total wall area possible is considered to be adequately ventilated (regardless of the type of floor).
b. A building or area is considered to be adequately ventilated provided it has neither a floor (for example, the floor is grating) nor a roof or ceiling.
c. A building or area is considered to be adequately ventilated provided it is without a roof or ceiling, and provided that there are no walls for a minimum of 25% of its perimeter.

6.6.2.4.8 Enclosed areas can be considered as adequately ventilated if the ventilation rate provided is at least four times the ventilation rate required to dilute the anticipated fugitive emissions to below 25 percent LFL, determined by detailed calculations as per Appendix B. If the ventilation rate provided is less than three air changes per hour, it is recommended that continuous monitoring with fixed gas detectors be provided to assure that less than 25 percent LFL is maintained. This ventilation rate can be accomplished by either natural or mechanical means.

Recirculation of inside air is permitted if:

a. the recirculated air is monitored continuously with a gas detection system meeting the requirements of Section 6.8.2a through h, and,
b. the gas detection system is designed to automatically stop recirculation, provide an alarm (audible or visual, or both, as most appropriate for the area), and provide exhaust (at a minimum rate as described in Par. 6.6.2.4.2) to the outside if gas- or vapor-air mixtures in concentration over 20 percent of their lower flammable limit (LFL) are detected.

Note: Sufficient dilution air must be added to the space in question to ensure that the concentration of flammable gas or vapor is maintained below 25 percent of the lower flammable limit (LFL) for all but abnormal conditions.

6.6.3 Inadequately Ventilated Areas

6.6.3.1 Inadequately ventilated areas are defined as rooms, buildings, or spaces that do not have a natural or a mechanical ventilation system providing for adequate ventilation as defined in Section 6.6.2.

6.6.3.2 It is possible to have portions of enclosed areas (e.g., buildings) adequately ventilated while other portions are inadequately ventilated. For example, the lower portion of a compressor building (shed) without walls (from the floor) might be adequately ventilated, while the upper portion of the shed (particularly if without ridge vents or the like) might be inadequately ventilated.

6.7 ADJACENT AREAS

6.7.1 A nonenclosed adequately ventilated area that is adjacent to a classified area, and that is not separated from the classified area by a vaportight barrier, should be classified to the extent designated by Section 8 through 14, as applicable. Reference Figure 2.

6.7.2 An enclosed area that is adjacent to a classified area, and that is separated from the classified area by a vaportight barrier, is unclassified, considering only the external source. Reference Figure 3.

6.7.3 An enclosed area that is adjacent to a classified area, and that is not separated from the classified area by a vaportight barrier, should be classified the same as the highest classification included. Reference Figures 4 and 5.

6.7.4 It may be possible to reduce the classification of an enclosed area adjacent to a classified area if the enclosed area is purged in accordance with NFPA 496.

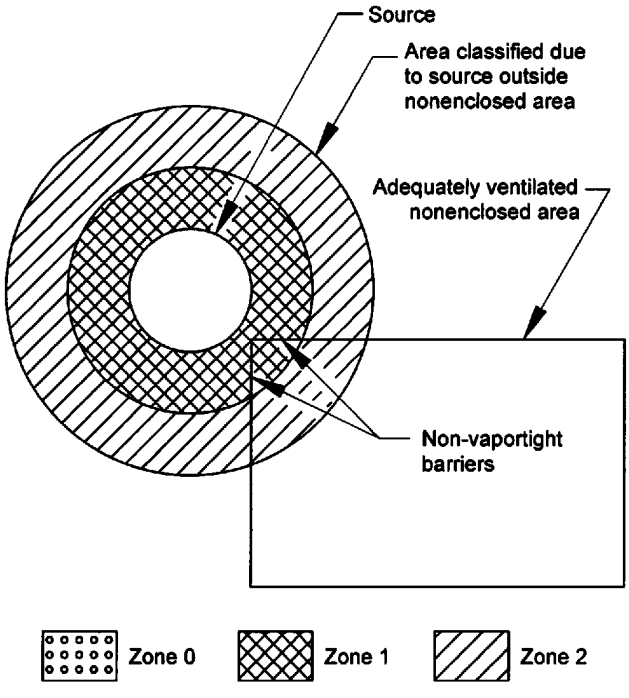


Figure 2—Adequately Ventilated Nonenclosed Area Adjacent to a Classified Area (See Section 6.7.1)

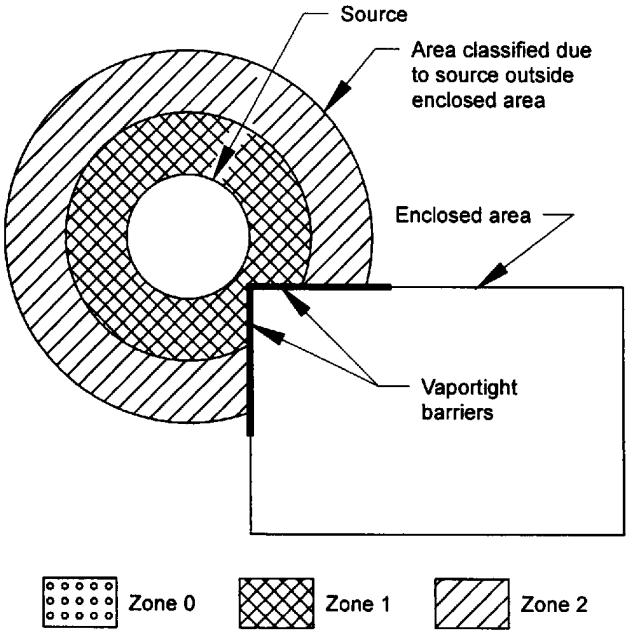


Figure 3—Enclosed Area Adjacent to a Classified Area (See Section 6.7.2)

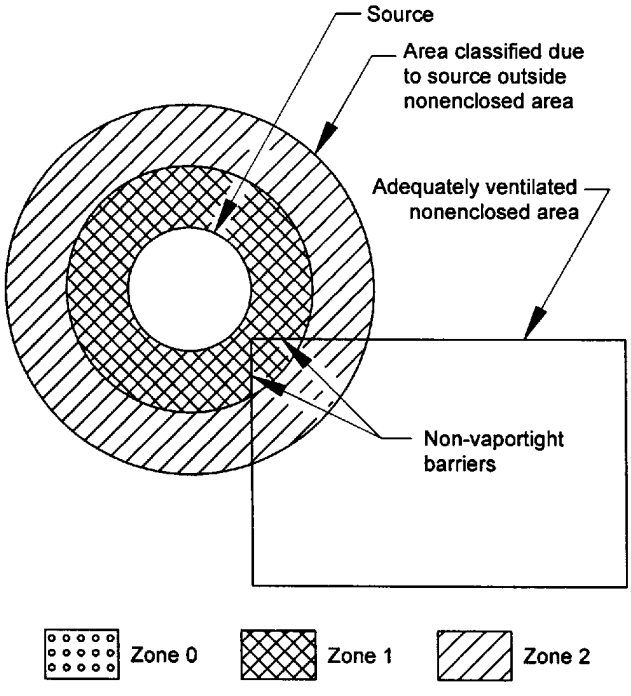


Figure 4—Enclosed Area Adjacent to a Classified Area (See Section 6.7.3)

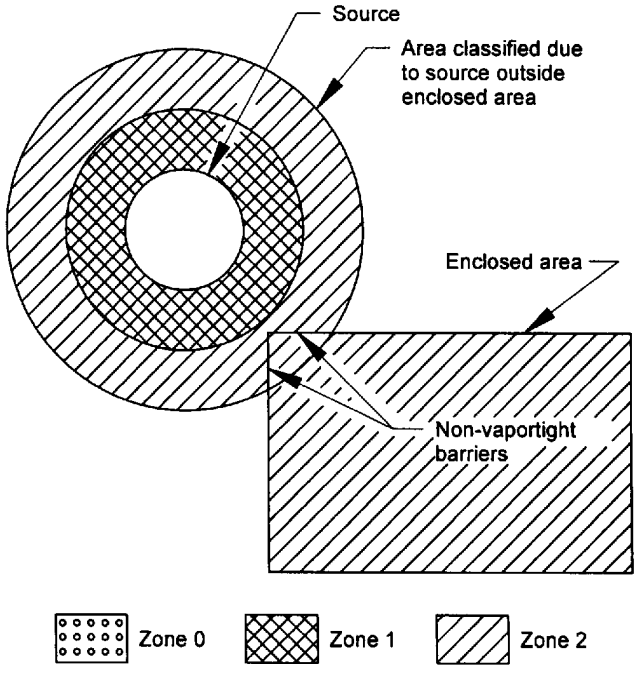


Figure 5—Enclosed Area Adjacent to a Classified Area (See Section 6.7.3)

6.8 USE OF COMBUSTIBLE GAS DETECTION EQUIPMENT

6.8.1 Provided the conditions of 6.8.2 are met, the installation of combustible gas detection equipment can be a basis for the following:

a. An inadequately ventilated area containing equipment that could release flammable gas or vapor can be designated as Zone 2.

Note: If an area contains equipment that may release flammable gases or vapors within the area during normal operations, gas detectors are not a feasible alternative unless some degree of ventilation is provided since frequent alarms or equipment shutdowns, or both, are likely to occur.

b. The interior of a building (or similar area) that does not contain a source of flammable gas or vapor can be considered unclassified, even though a door or similar pierced portion or all of the outside of the building is located in a Zone 2 area, provided the building is of a type construction that is essentially vaportight; that is, the building will not allow the entry of significant quantities of outside atmospheric pressure gas or vapor. Buildings made of fiberglass (molded fiberglass or fiberglass sprayed over wood) or seal welded steel plate normally are used to meet this criteria, but other construction methods may be equally satisfactory. Penetrations should be minimized—normally limited to a personnel entry door(s), electrical cable entries, air conditioning unit(s), and the like. The buildings should contain no windows that can be opened, and the personnel entry door(s) should be provided with ade-

quate gaskets or weather stripping. Openings for air conditioning units and windows should be adequately caulked or otherwise made vaportight. Air conditioning equipment must not introduce outside air into the building. Entries for cables and other services should be made in a vaportight manner.

6.8.2 The criteria for use of combustible gas detection equipment to meet the objectives of 6.8.1 follow:

a. the gas detectors are of a stationary type, permanently mounted; portable gas detectors will not satisfy this requirement;

b. the gas detection equipment is of a type approved or listed by a nationally recognized testing laboratory (NRTL). It is recommended that equipment meet ANSI/ISA S12.13, Part 1, Performance Requirements, Combustible Gas Detectors;

c. an adequate number of sensors is installed to ensure the sensing of flammable gas or vapor in the building (or similar area) in all areas where such gas might accumulate;

Note: For offshore production and drilling operations, refer to API RP 14C.

d. sensing a gas concentration of 20 percent LFL (or less) should activate a local alarm (audible or visual, or both, as most appropriate for the location);

Note: It may be desirable to initiate remedial action at this level to avoid reaching the 40 percent LFL level, which requires power disconnection as detailed in 6.8.2.e.

e. sensing a gas concentration of 40 percent LFL (maximum) or a gas detector system malfunction should both activate an alarm (audible or visual, or both, as most appropriate for the area) and initiate automatic disconnection of power from all electrical devices in the area that are not suitable for Zone 2. The power disconnecting device(s) should be suitable for Class I, Zone 1 if located inside the building (or similar area); if the disconnecting device(s) is located outside the building (or similar area), it should be suitable for the area in which it is located. Redundant or duplicate components (such as sensors) may be installed to avoid disconnecting electrical power when single component malfunctions are indicated. When automatic shutdown could introduce additional or increased hazard, this technique of area classification reduction should not be used;

Note: In the case of sensing 40 percent LFL or a gas detection system malfunction, corrective action to reduce the gas concentration should be initiated immediately.

f. the gas detectors should be calibrated at a frequency in accordance with the manufacturer's recommendations, but at least once every three months. Calibration should be performed by actual exposure of the sensor to a known mixture (nominal 50 percent LFL recommended) of diluent and methane or other gas anticipated, in accordance with the manufacturer's recommendations;

g. user-provided systems bypassing the disconnecting or other "corrective action" devices (but not audible or visual alarm devices) to allow calibration and maintenance are permitted, provided the bypass system is utilized only during calibration or maintenance operations, and only while the area is manned by personnel who are qualified to take corrective action should there be a malfunction in process, storage, transfer, or similar equipment that potentially might release flammable gas or vapor into the area. Any systems in the bypass mode must be made continuously obvious (audibly or visually) to facility personnel; and

h. the building (or similar area) contains no electrically heated parts or components (not enclosed in explosionproof or flameproof enclosures or otherwise suitable for Zone 1 applications) that may operate at a temperature equal to or above 80 percent of the ignition temperature (expressed in degrees C) of the gas or vapor involved unless the component has been verified by a nationally recognized testing laboratory (NRTL) to operate below the ignition temperature of the gas or vapor.

Note: Electrically heated parts and components could remain at or above the ignition temperature for some time after de-energization.

6.8.3 It is recommended that gas detectors be installed, operated, and maintained in accordance with ANSI/ISA RP 12.13, Part II, Installation Operation and Maintenance of Combustible Gas Detection Instruments.

7 Extent of a Classified Location

7.1 GENERAL

7.1.1 Locations are classified solely for the selection, design, and installation of electrical equipment.

Note: Although electrical area classification drawings may be useful to assist in determining designated welding areas, smoking areas, and the like, they do not contain all the information that is necessary for making decisions for designating such locations. It should not be implied that it is safe to have non-electrical sources of ignition in unclassified locations.

7.1.2 The volume, temperature, and volatility of liquid or gas that could be released, the nature of the leak source, and the rate at which it could be released, are of extreme importance in determining the extent of a classified location. Sound engineering judgment is required to properly determine the extent of classified locations.

7.1.3 In most petroleum facilities, there are sources of ignition in addition to those associated with electrical equipment (for example, piping systems and engine manifolds operated at elevated temperatures and unprotected fired vessels). The extent of classified locations is determined only by the location of potential sources of release of flammable liquids, gases, and vapors, and not by the location of sources of ignition—electrical or non-electrical.

7.2 OUTDOOR LOCATIONS

7.2.1 In the absence of walls or other barriers, and in the absence of air currents or similar disturbing forces, it must be assumed that a gas or vapor will disperse uniformly in all directions, as governed by the gas or vapor density and velocity (that is, heavier-than-air vapors principally downward and outward; lighter-than-air gases principally upward and outward).

7.2.2 For heavier-than-air vapors released at or near grade level, the locations where potentially ignitible concentrations are most likely to be found are below grade; those at grade are next most likely; and as the height above grade increases, the potential decreases. In open locations away from the immediate point of release, freely drifting heavier-than-air vapors from a source near grade seldom are above the lower flammable limits at elevations more than a few feet above grade. For lighter-than-air gases the opposite is true; there is little potential of an ignitible mixture below grade, and greater potential above grade.

Note: Gases, vapors, and combinations of gases and vapors must be carefully analyzed to determine whether they are heavier- or lighter-than-air under all operating conditions. Mixtures often contain both lighter-than-air and heavier-than-air components.

7.2.3 Elevated or below grade sources of gas or vapor release, or release of gas or vapor under pressure, may substantially alter the outline of the limits of the classified location. Also, low velocity movement (e.g., movement caused by a mild breeze) may extend these limits in the direction of air movement. However, higher velocity air movement (e.g., a stronger breeze) can so accelerate the dispersion of gases or vapors that the extent of the classified location would be greatly reduced. The nature of the release (that is, whether it is a high pressure spray-type mist or a low velocity stream or drip) also has a significant impact on the extent of the classified location. Thus, dimensional limits recommended for Zone 0, Zone 1, and Zone 2 locations are based on experience, as well as theoretical diffusion of gases or vapors of the types prevalent in petroleum operations. There are several techniques available to aid in the analysis of gas and vapor dispersion, including specific plant experience and computer simulation programs. These techniques may be used with good engineering judgment to modify standard area classification boundaries for specific applications. Reference Appendix D for one such technique.

7.2.4 Air currents, quantity of release, nature of release, and volatility combine to affect the extent of a classified location. Vapors are rapidly dispersed in a well ventilated location. For this reason, outdoor locations and locations having ventilation equivalent to normal outdoor conditions often can be classified as Zone 2 or unclassified. However, where ventilation is inadequate, vapor-air and gas-air mixtures are more likely to reach flammable limits, and the situation may justify a larger classified area.

7.3 ENCLOSED LOCATIONS

Some enclosed locations (e.g., buildings) used for petroleum operations have mechanical ventilation provided. Also, construction design may permit a substantial degree of natural ventilation that, when coupled with such factors as volumetric content of the enclosed location, floor area, lineal dimensions of walls, and ceiling height could justify considering that enclosed location as adequately ventilated. If adequate ventilation is provided, mechanically or naturally, many enclosed locations may be classified Zone 2 instead of Zone 1, and some locations may be classified Zone 1 instead of Zone 0. A careful evaluation of prior experience with the same or similar types of installations, including the temporary use of tarpaulins or similar devices as windbreaks, should always be a part of the classification criteria.

8 Recommendations for Determining Degree and Extent of Classified Locations—Common Applications

8.1 GENERAL

8.1.1 This section presents guidelines for classifying locations for electrical installations common in many petroleum facilities. The examples have been developed by experience in industry and are applicable to most petroleum facilities. Sections 9 through 14 provide guidance for classifying locations within specific refining, production, and transportation facilities.

8.1.2 Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing information presented in this recommended practice and other publications.

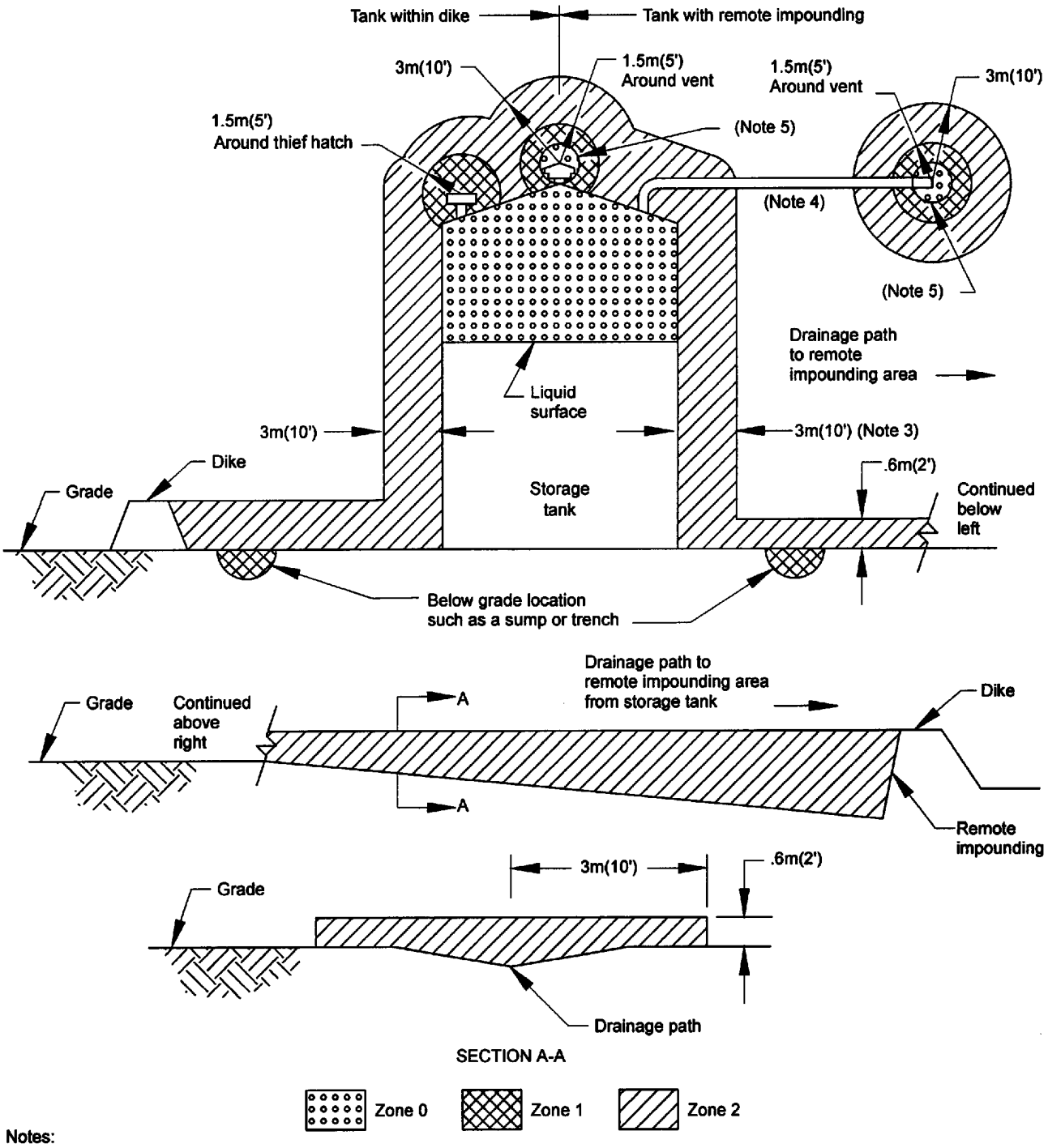
8.2 RECOMMENDATIONS FOR AREAS SURROUNDING SPECIFIC EQUIPMENT

8.2.1 Storage Tanks

8.2.1.1 Fixed Roof Flammable Liquid Storage Tanks

8.2.1.1.1 Areas in and around flammable liquid storage tanks in nonenclosed adequately ventilated areas are classified as shown in Figure 6. Reference 5.2 for a discussion of "Flammable Liquids."

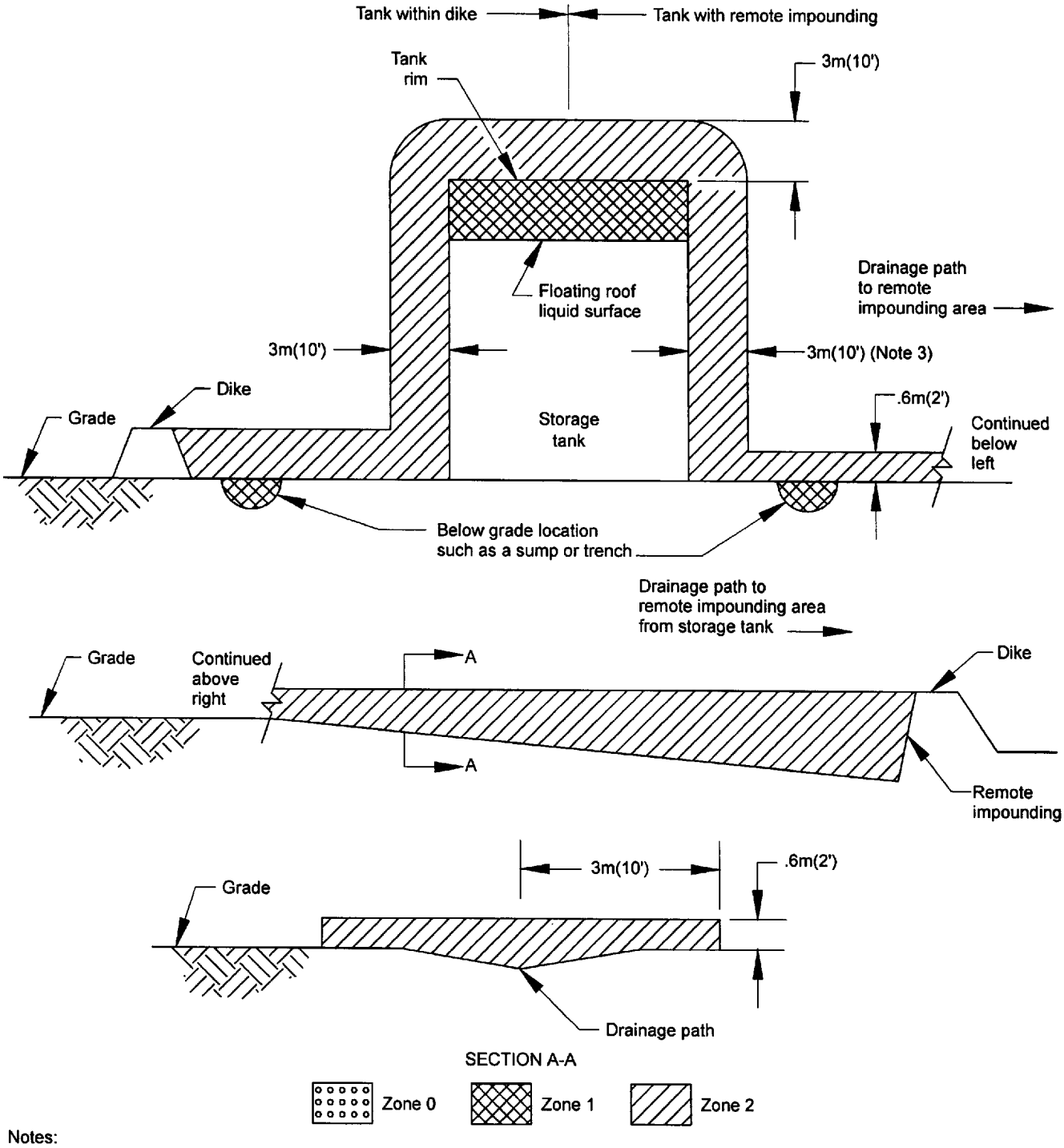
8.2.1.1.2 Areas surrounding fixed roof flammable liquid storage tanks in adequately ventilated enclosed areas are classified as shown in Figure 6, but with the remainder of the enclosed area designated as Zone 2, provided all vents are



Notes:

1. High filling rates or blending operations involving Class I flammable liquids may require extending the boundaries of classified areas.
2. Distances given are for typical petroleum facilities: they must be used with judgement, with consideration given to all factors discussed in the text.
3. Zone 2 area extends 3 meters (10 feet) horizontal distance from the tank shell (only) if there is no dike and there is no remote impounding.
4. The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.
5. An area .5 meters (18 inches) around vents is classified Zone 0.

Figure 6—Fixed Roof Flammable Liquid Storage Tank in a Nonenclosed, Adequately Ventilated Area (See Section 8.2.1.1.1)



Notes:

1. High filling rates or blending operations involving Class I flammable liquids may require extending the boundaries of classified areas.
2. Distances given are for typical petroleum facilities: they must be used with judgement, with consideration given to all factors discussed in the text.
3. Zone 2 area extends 3 meters (10 feet) horizontal distance from the tank shell (only) if there is no dike and there is no remote impounding.

Figure 7—Open Top Floating Roof Flammable Liquid Storage Tank in a Nonenclosed, Adequately Ventilated Area (See Section 8.2.1.2)

extended to the outside of the enclosed area and there are no hatches or similar devices inside the enclosed area.

8.2.1.1.3 Areas inside fixed roof flammable liquid storage tanks in inadequately ventilated enclosed areas are classified Zone 0 and areas surrounding the tank Zone 1 as shown in Figure 6, and also Zone 1 outside the tank to the extent of the enclosed area.

8.2.1.2 Open Top Floating Roof Flammable Liquid Storage Tanks

8.2.1.2.1 Areas in and around open top floating roof flammable liquid storage tanks in nonenclosed adequately ventilated areas are classified as shown in Figure 7. Reference 5.2 for a discussion of "Flammable Liquids."

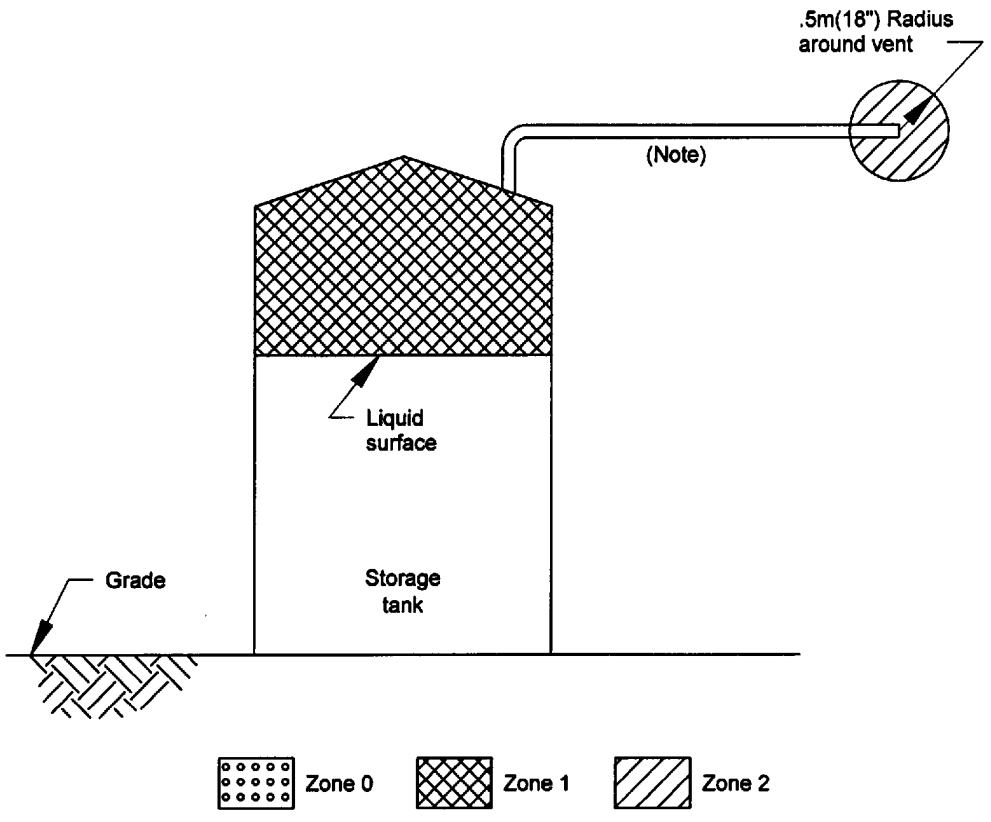
8.2.1.2.2 Areas in and around open top floating roof flammable liquid storage tanks in adequately ventilated enclosed areas are classified as shown in Figure 7, but with the remainder of the enclosed area designated as Zone 2, provided all vents are extended to the outside of the enclosed area and there are no hatches or similar devices inside the enclosed area.

8.2.1.2.3 Areas in and around open top floating roof flammable liquid storage tanks in inadequately ventilated enclosed areas are classified Zone 0 inside the tank as shown in Figure 7, but also Zone 0 outside the tank to the extent of the enclosed area.

8.2.1.3 Combustible Liquid Storage Tanks

8.2.1.3.1 Unheated storage tanks for combustible liquids (e.g., diesel fuel and Jet A fuel) in nonenclosed adequately ventilated areas are classified as shown in Figure 8. Reference Section 5.2 for a discussion of "Combustible Liquids."

8.2.1.3.2 Enclosed areas containing unheated storage tanks for combustible liquids are unclassified provided all vents are extended to the outside of the enclosed area.



Note:

The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.

Figure 8—Combustible Liquid Storage Tank in a Nonenclosed Adequately Ventilated Area (See Section 8.2.1.3)

8.2.1.3.3 The area surrounding the vents is classified to allow for the possibility that the surface of the liquid might be heated above its flash point by the ambient. The area surrounding the vents need not be classified if the liquid will be handled and stored below its flash point.

8.2.2 Tank Cars and Tank Trucks

8.2.2.1 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring liquefied gas, compressed gas or cryogenic liquid only through the dome, are classified as shown in Figure 9.

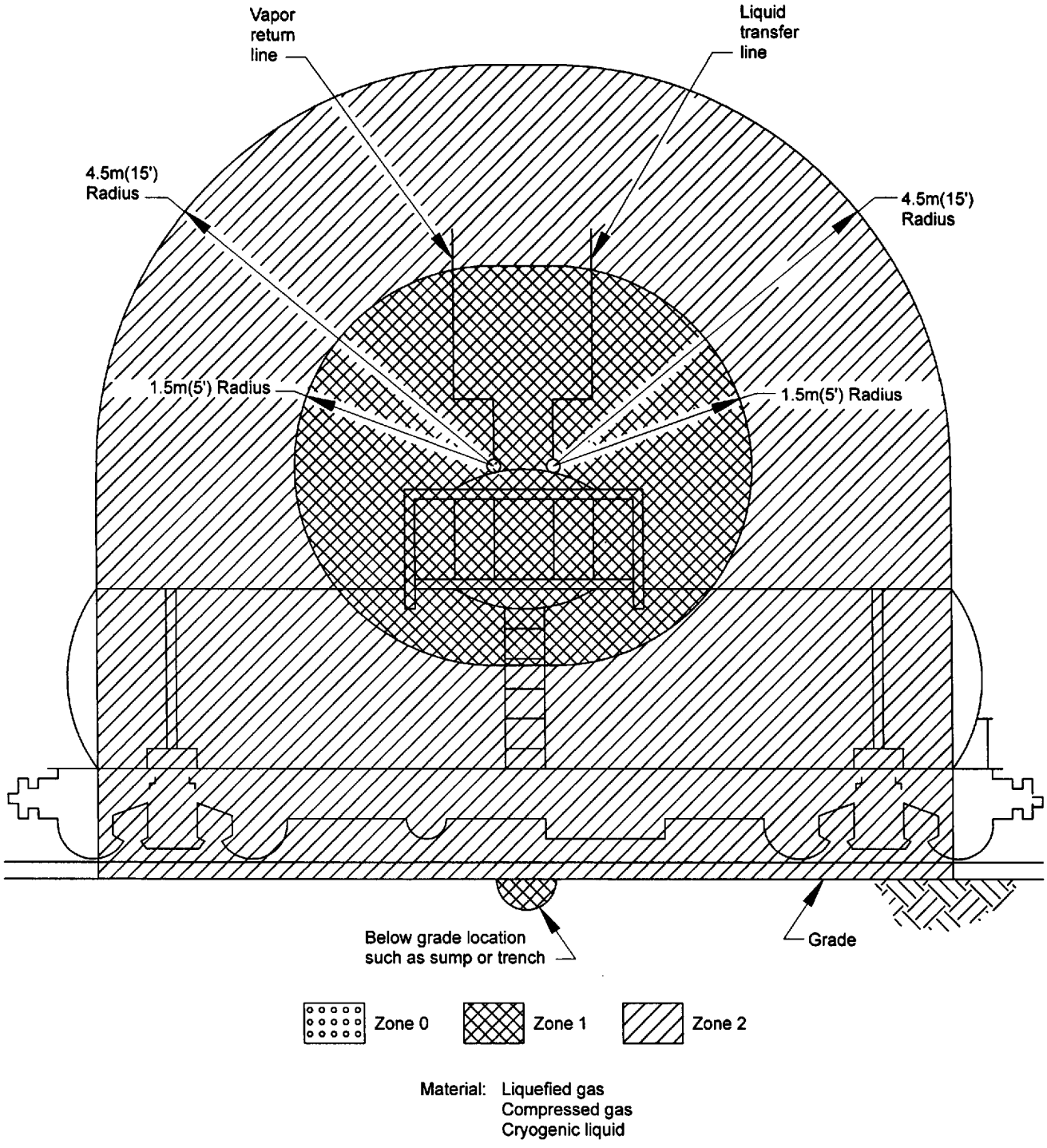


Figure 9—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Dome Only (See Section 8.2.2.1)

8.2.2.2 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring flammable liquids only through the dome, are classified as shown in Figure 10.

8.2.2.3 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring flammable liquid only through the bottom, are classified as shown in Figure 11.

8.2.2.4 Locations where tank cars or tank trucks are loaded or unloaded via open systems, transferring flammable liquid through the top or the bottom, are classified as shown in Figure 12.

8.2.2.5 Locations where tank cars or tank trucks are loaded or unloaded via closed systems, transferring liquefied gas, compressed gas or cryogenic liquid only through bottom transfer, are classified as shown in Figure 13.

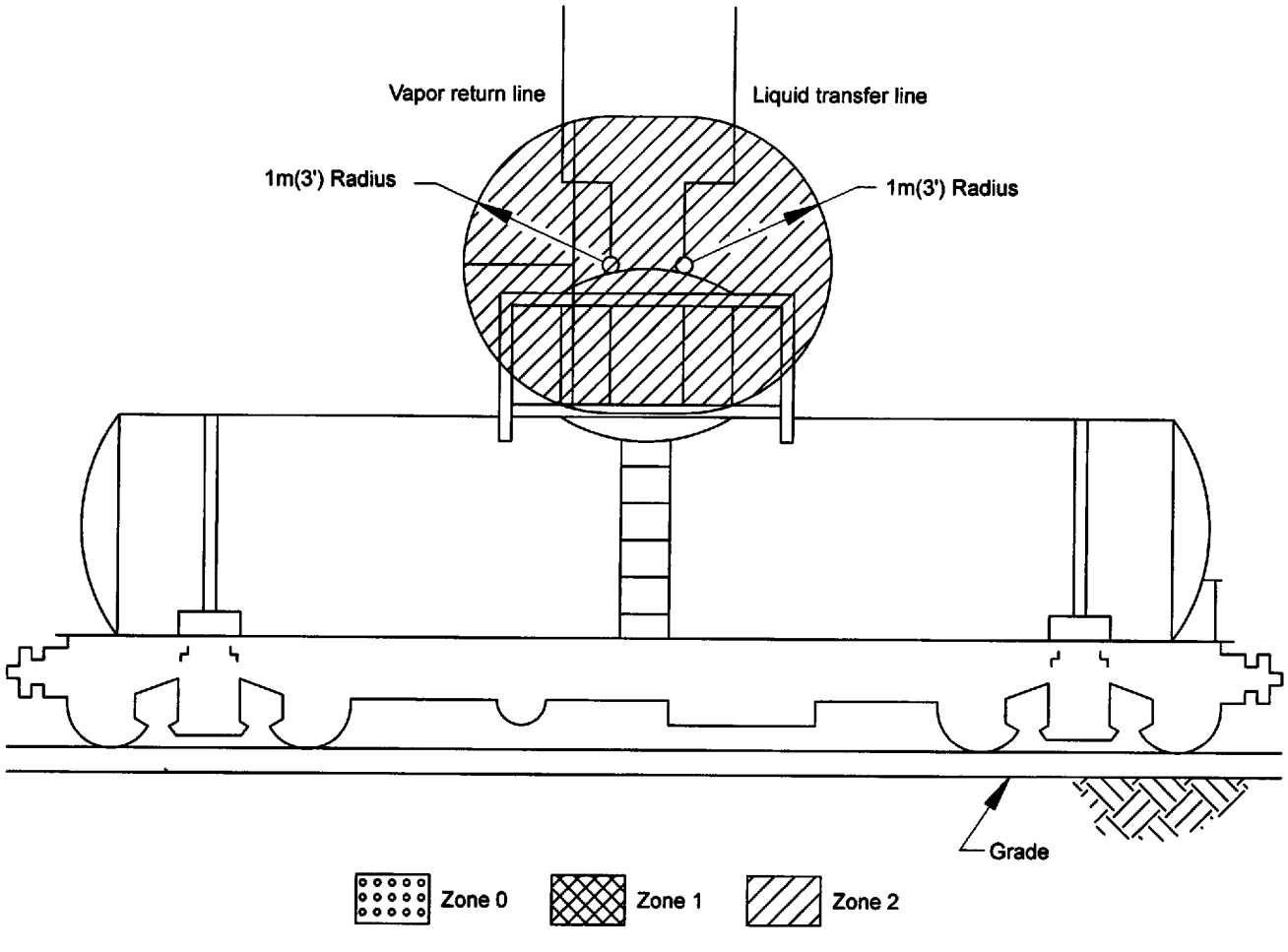


Figure 10—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Dome Only
(See Section 8.2.2.2)

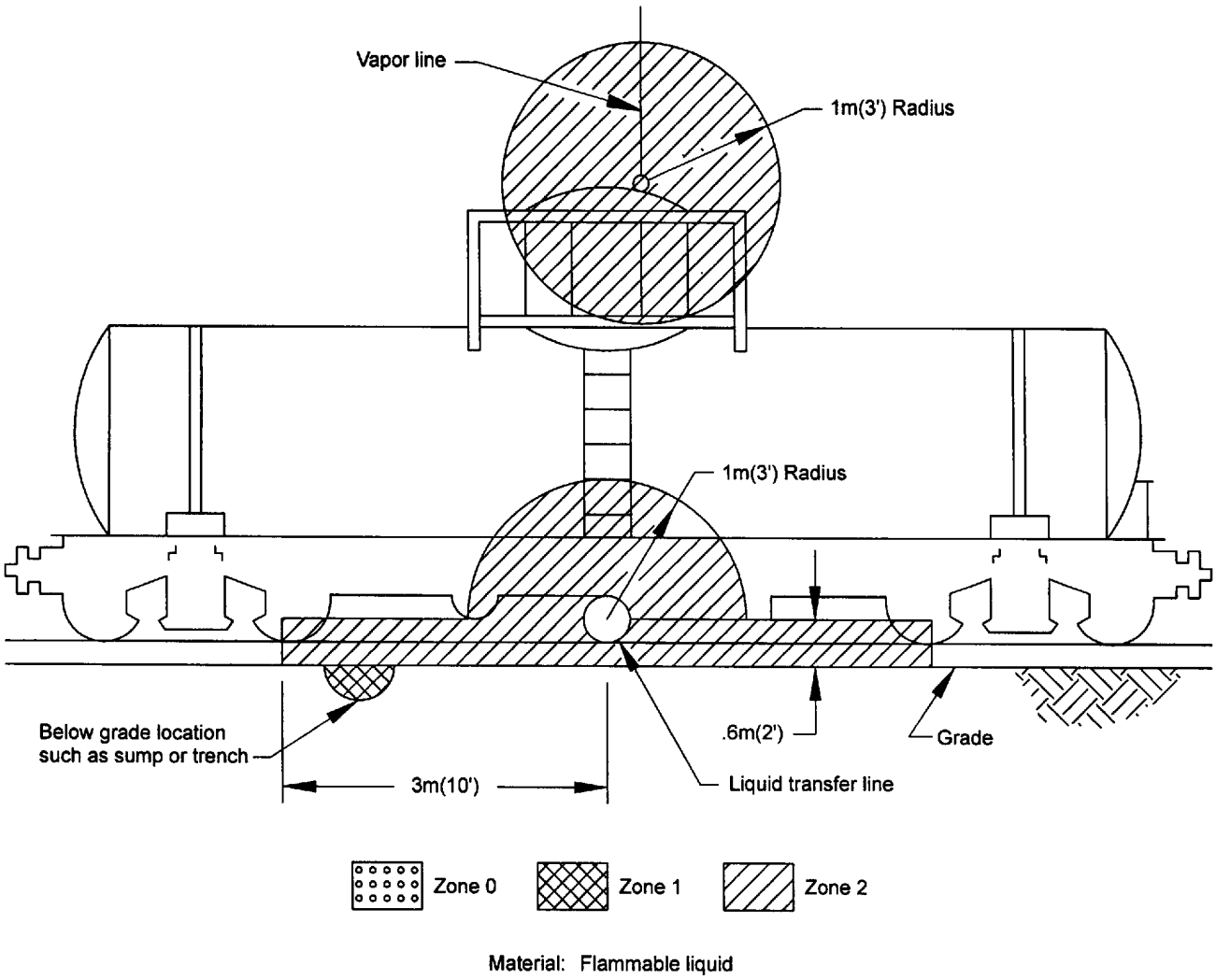


Figure 11—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Bottom Only
(See Section 8.2.2.3)

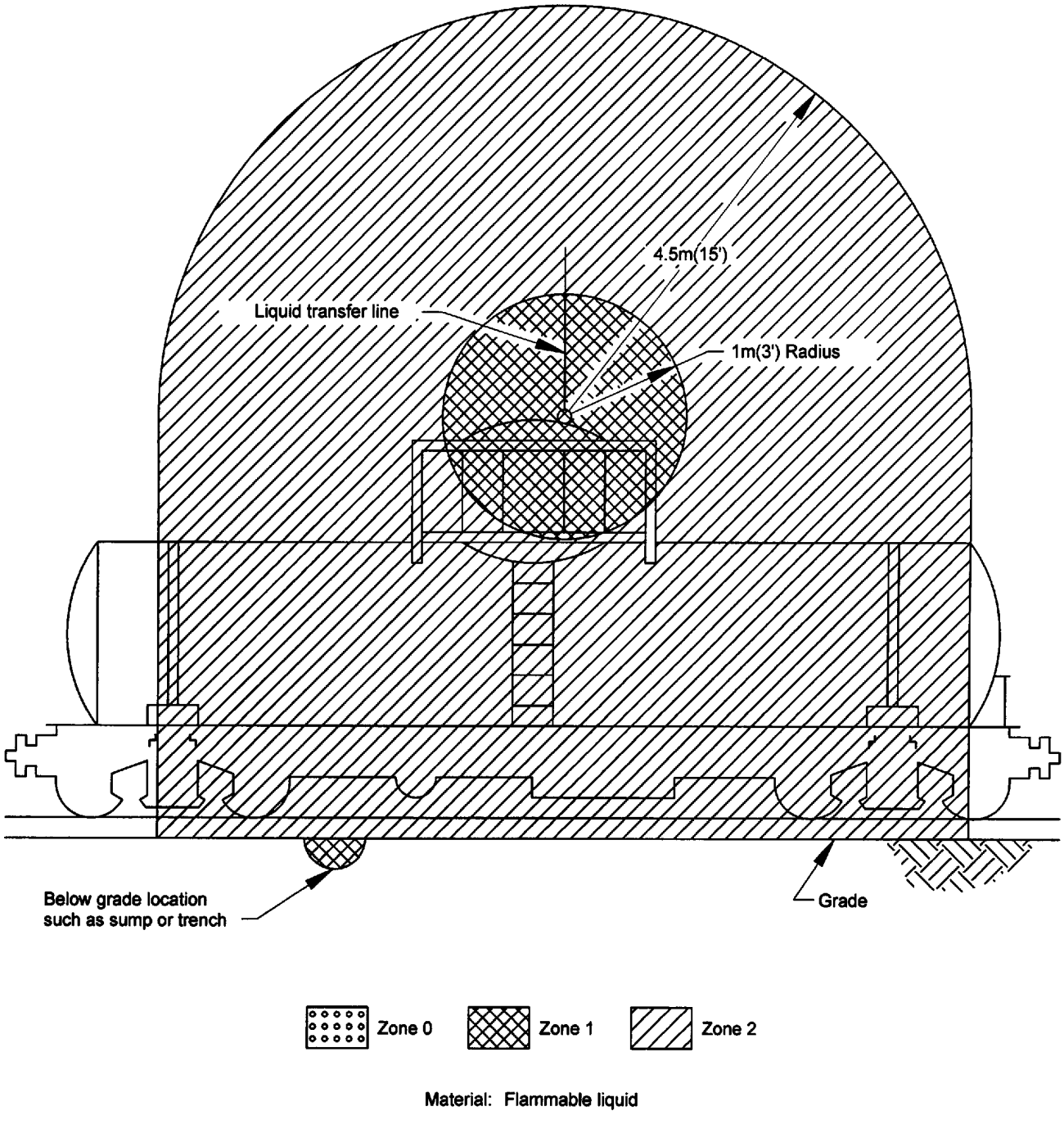


Figure 12—Tank Car or Tank Truck Loading and Unloading Via Open System. Product Transfer Through Top or Bottom
(See Section 8.2.2.4)

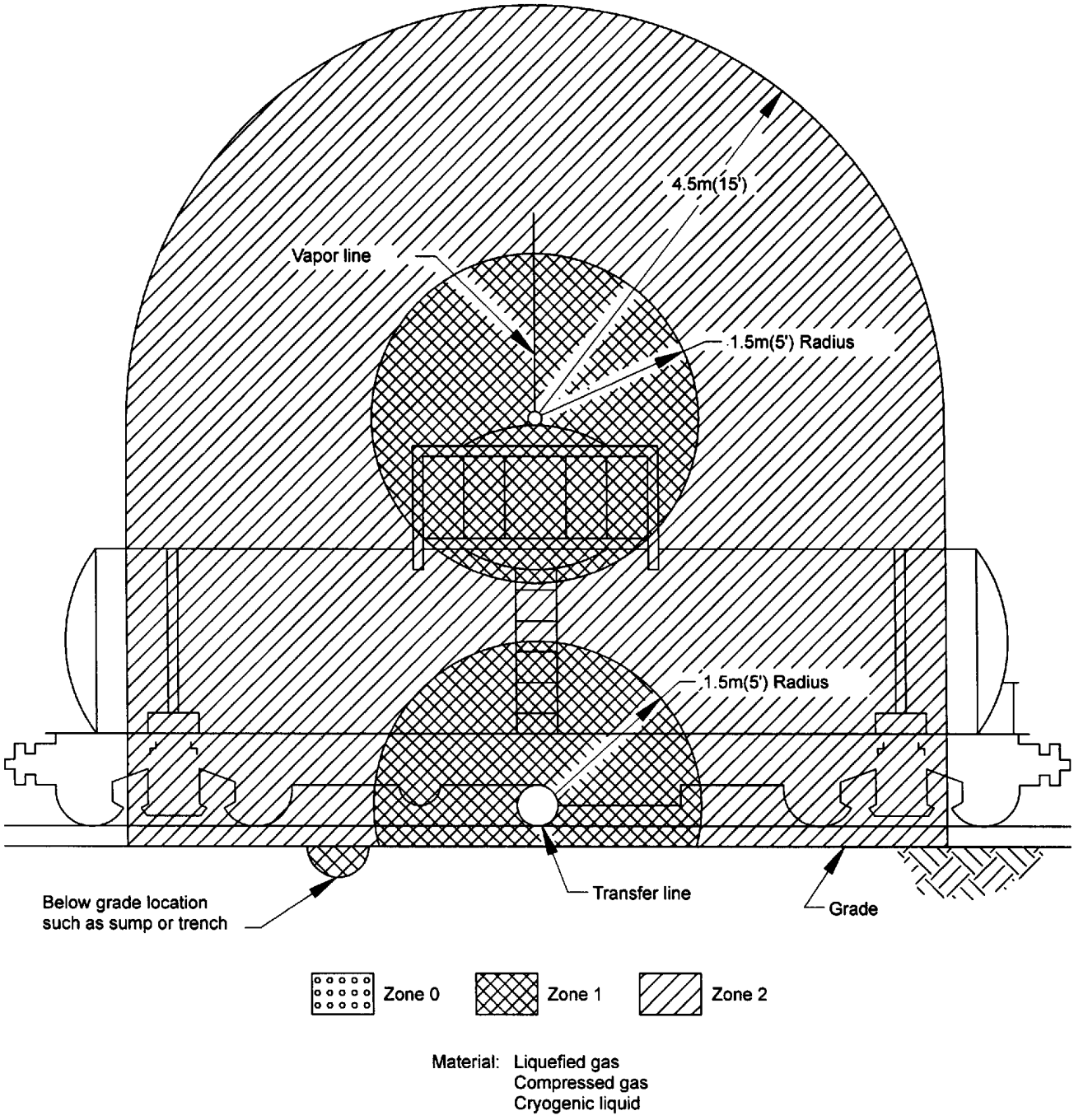


Figure 13—Tank Car or Tank Truck Loading and Unloading Via Closed System. Product Transfer Through Bottom Only
(See Section 8.2.2.5)

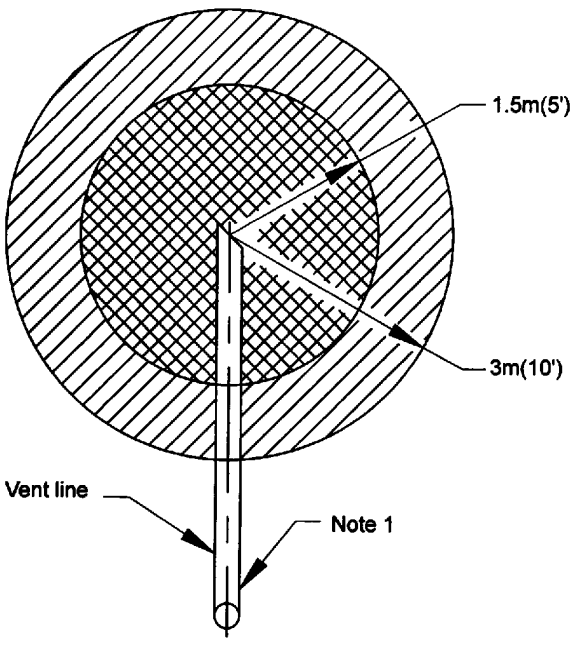
8.2.3 Vents, Relief Valves, and Rupture Disks

Note: This section assumes that the process equipment and instrument and control device vent sources cited are "continuous," referred to in ISA RP12.24.01 Section 4.3 (IEC 79-10 Mod), as a continuous "Grade of Release." [Excerpt: The likelihood of the presence of an explosive gas atmosphere, and hence the type of zone, depends mainly on the grade of release and the ventilation. Note—A continuous grade of release normally leads to a Class I, Zone 0, a primary grade to Class I, Zone 1 and a secondary grade to Class I, Zone 2 location.] If the grade of release is NOT continuous, good engineering judgment normally would dictate a lesser hazardous location—for example, Zone 1 instead of Zone 0. Reference ISA RP12.24.01 and Appendix D of this document for further guidance.

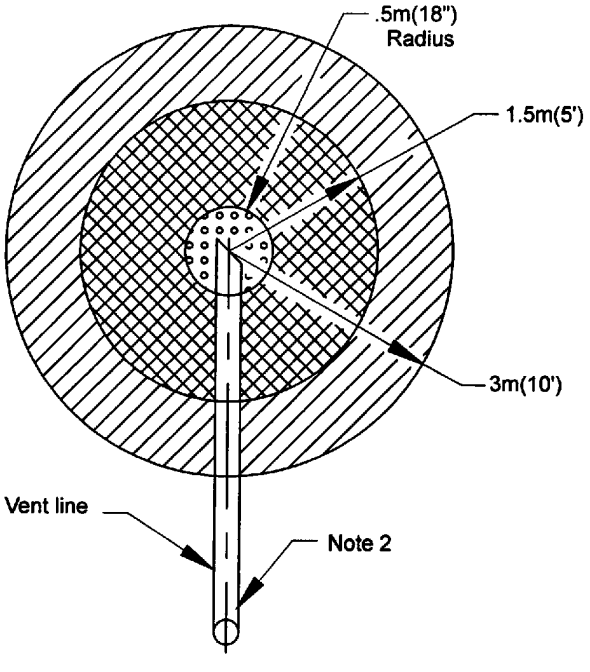
8.2.3.1 Process Equipment Vents

8.2.3.1.1 The criteria affecting the extent of the classification of the areas around process equipment vents in nonenclosed areas are too diverse to specify distances. Individual engineering judgment is required for specific cases, but in no case should the classification be less than that shown by Figure 14.

8.2.3.1.2 Enclosed areas containing process equipment vents are classified Zone 1 to the extent of the enclosed area.



A. Vents not subject to discharging continuously or for long periods of time.



B. Vents discharging continuously or for long periods of time.

Notes:

1. The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.
2. The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.

Figure 14—Process Equipment Vent in a Nonenclosed Adequately Ventilated Area (See Section 8.2.3.1)

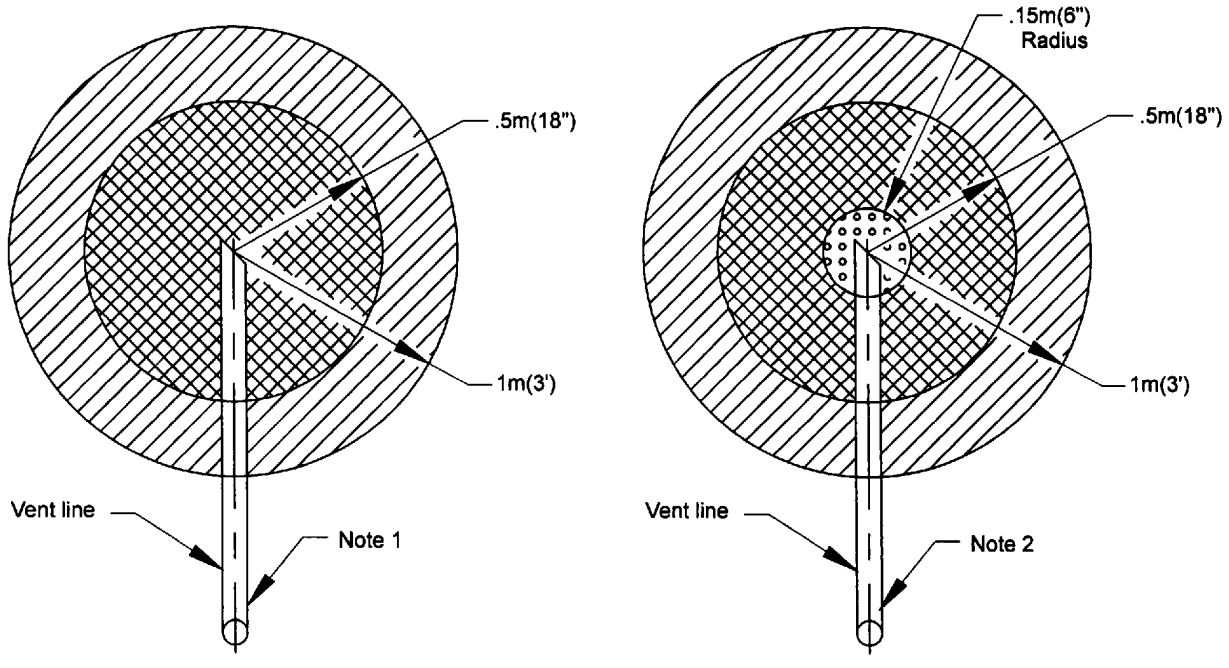
8.2.3.2 Instrument and Control Device Vents

8.2.3.2.1 Adequately ventilated nonenclosed areas containing vents from instruments and control devices utilizing flammable gas for control are classified as shown in Figure 15.

8.2.3.2.2 Enclosed areas containing vents from instruments and control devices utilizing flammable gas for control are classified Zone 0 to the extent of the enclosed area.

8.2.3.3 Atmospheric Vents

8.2.3.3.1 Atmospheric vents (e.g., building ridge vents, building roof vents, and atmospheric tank vents) venting from a Zone 0 area are classified in a manner similar to that shown in Figure 16, except they should be surrounded by a Zone 0 classification for a distance of 50 cm (18 in). The Zone 0 classification should be surrounded by a Zone 1 classification for a distance of 1 m (3 ft), which, in turn, should be surrounded by a Zone 2 classification of 1.5 m (5 ft).



A. Vents not subject to discharge continuously or for long periods of time.

B. Vents discharging continuously or for long periods of time.

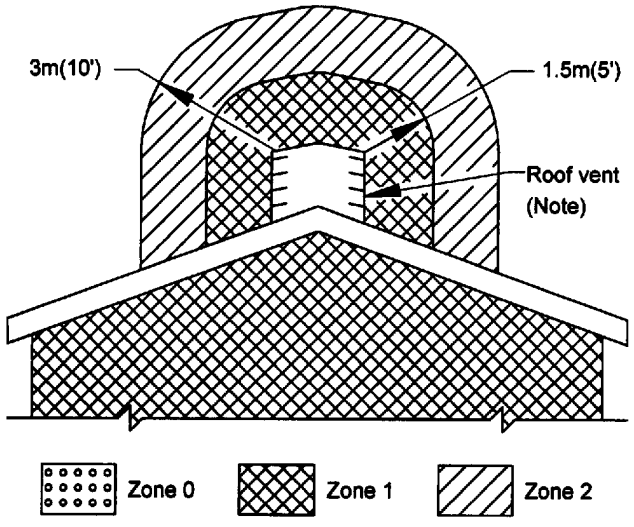
Notes:

1. The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.
2. The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.

Figure 15—Instrument or Control Device Vent in a Nonenclosed Adequately Ventilated Area (See Section 8.2.3.2)

8.2.3.3.2 Atmospheric vents (e.g., building ridge vents, building roof vents, and atmospheric tank vents) are classified as shown in Figure 16 when they vent from a Zone 1 area.

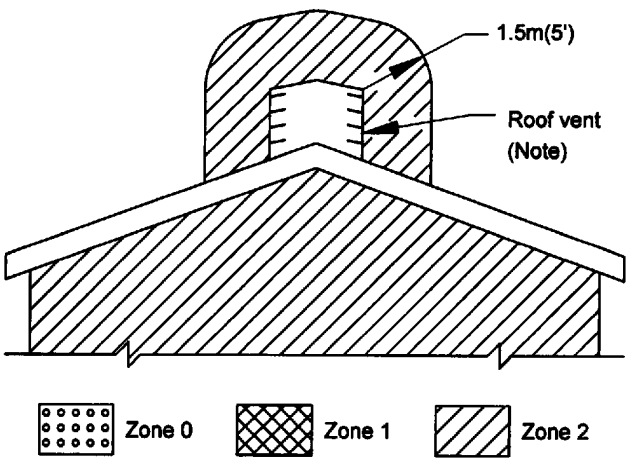
8.2.3.3.3 Atmospheric vents (e.g., building ridge vents and building roof vents) are classified as shown in Figure 17 when they vent from a Zone 2 area.



Note:

The interior of the roof vent is Zone 1.Cross hatching has been omitted for drawing clarity.

Figure 16—Atmospheric Vent From a Zone 1 Area (See Section 8.2.3.3.2)



Note:

The interior of the roof vent is Zone 2. Cross hatching has been omitted for drawing clarity.

Figure 17—Atmospheric Vent From a Zone 2 Area (See Section 8.2.3.3.3)

8.2.3.4 Relief Valves and Rupture Disks

8.2.3.4.1 The criteria affecting the extent of the classification of the areas around relief valve vents in nonenclosed areas are too diverse to specify distances. Individual engineering judgment is required for specific cases, but in no case should the classification be less than that shown by Figure 18.

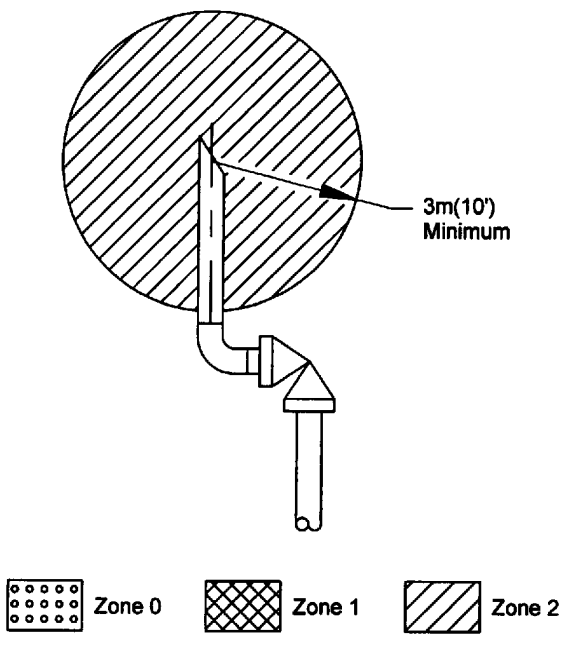
8.2.3.4.2 Enclosed areas containing relief valve vents are classified Zone 1 to the extent of the enclosed area.

8.2.3.4.3 Rupture disks should be considered the same as relief valves.

8.2.4 MARINE TERMINAL HANDLING FLAMMABLE LIQUIDS

8.2.4.1 Marine terminals handling flammable liquids are classified as shown in Figure 19.

8.2.4.2 The source of gas is primarily from tanker (or barge) cargo tank vents and ullage (gauging and sampling) openings during loading and unloading. These criteria do not apply if flammable gases or vapors are not vented (for example, when unloading without cargo tank ballasting). The extent of the classified area is based on the longest tanker that



Note:

The interior of the vent piping above relief valve is Zone 2. Cross hatching has been omitted for drawing clarity.

Figure 18—Relief Valve in a Nonenclosed Adequately Ventilated Area (See Section 8.2.3.4)

the berth can accommodate. When water level changes may result in gases or vapors from cargo tank vents or ullage openings collecting underneath the berth deck, consideration should be given to classifying this space as Zone 1.

8.2.5 Hydrocarbon-Fueled Prime Movers

8.2.5.1 Adequately ventilated enclosed areas containing gas-fueled or diesel-fueled engines/turbines need not be classified solely by reason of the engine/turbine fuel as per NFPA 37.

8.2.5.2 It is recommended that the reader also reference NFPA 850, *Recommended Practice for Fire Protection for Fossil Fueled Steam Electric Generating Plants.* NFPA 850 provides recommendations (not requirements) for fire prevention and fire protection for gas, oil, or coal-fired electric generating plants used for electric generation. NFPA 850 does not address the specific issue of area classification due to liquid or gaseous fuel, but it would be prudent to review the safety recommendations of both NFPA 37 and NFPA 850 when designing generating stations.

8.2.5.3 Associated non-fuel handling equipment must be considered separately.

8.2.5.4 Pneumatic starters utilizing flammable gas for the power medium should be classified the same as flammable gas-operated instruments; see Section 10.11.2. The discharge of their vents should be considered the same as the discharge of process equipment vents; see Section 8.2.3.1.

8.2.5.5 Gas pressure regulators, shutdown valves, and similar equipment in non-fuel service should be classified according to the appropriate portions of Sections 8 through 14.

8.2.5.6 Gas scrubbers in non-fuel service should be classified the same as hydrocarbon pressure vessels. Gas filter-separators in non-fuel service should be classified the same as launchers or receivers.

8.2.6 Batteries

8.2.6.1 This section presents guidelines for classifying locations where batteries are installed. Areas classified solely because they contain batteries are classified because of hydrogen evolution from the batteries, and, therefore, require a Group IIC designation.

8.2.6.2 Areas containing non-rechargeable batteries do not require area classification solely due to the presence of the batteries.

8.2.6.3 Enclosed areas containing rechargeable batteries that (1) have no vents, (2) are of the nickel-cadmium or nickel-hydride type, (3) have a total volume less than one-hundredth of the free volume of the enclosed area, and (4) have a capacity not exceeding 1.5 ampere-hours at a one hour discharge rate, do not require area classification solely due to the presence of the batteries.

Note: For the purpose of area classification, battery vents include relief devices, such as valves that open to the atmosphere, as found in valve-regulated lead acid (VRLA) batteries.

8.2.6.4 Enclosed areas containing rechargeable batteries that (1) have no vents, and (2) either (a) have a total volume less than one-hundredth of the free volume of the enclosed area, or (b) have a charging system that has a rated output of 200 watts or less and that is designed to prevent inadvertent overcharging, do not require area classification solely due to the presence of the batteries.

8.2.6.5 A nonenclosed adequately ventilated location containing batteries is unclassified.

8.2.6.6 An enclosed location containing rechargeable batteries is unclassified provided all batteries are vented either directly or indirectly to the outside of the enclosed area.

8.2.6.6.1 Directly-vented systems vent evolved hydrogen directly from the batteries to the outside utilizing vent tubing systems or similar apparatus.

8.2.6.6.2 Indirectly-vented systems (1) collect evolved hydrogen in battery boxes (electrical enclosures designed to enclose batteries), which, in turn, are vented outside of the enclosed area, or (2) utilize systems such as hood vents (or other systems that perform similar functions) that collect evolved hydrogen and vent it to the outside of the enclosed area.

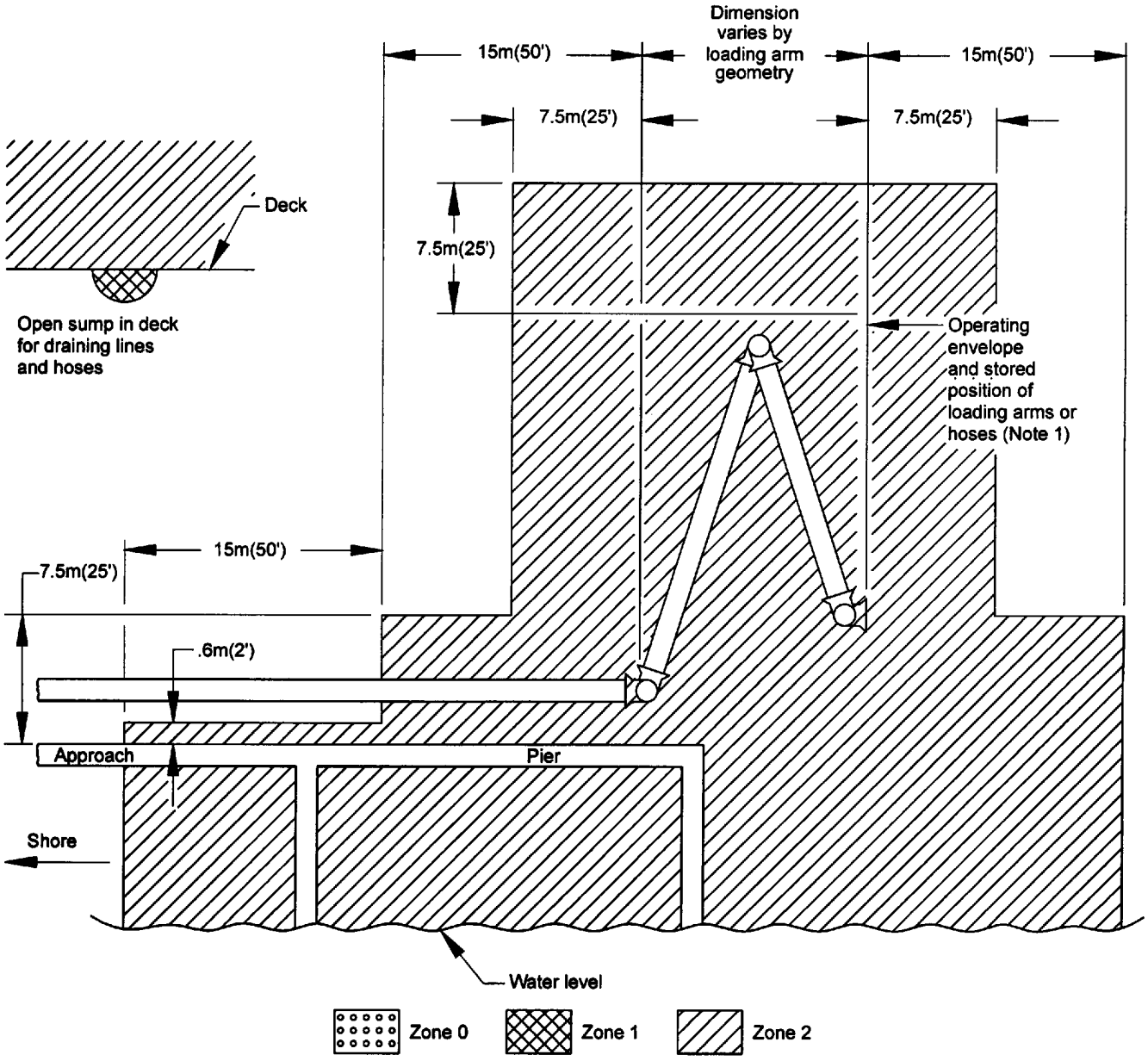
8.2.6.6.2.1 The interior of battery boxes should be unclassified provided: (a) the battery boxes have vent(s) with a cross-sectional area of not less than 6.45 square centimeters (one square inch) for every 0.14 cubic meters (5 cubic feet) of battery box volume, (b) the vent(s) is not more than 45 degrees from vertical for any point except wall penetrations, and (c) the vent(s) extends from the highest point of the battery box.

Note: Wall penetrations include penetrations through the walls of the battery boxes and through the walls of the buildings (or similar enclosed areas) in which the battery boxes are installed.

8.2.6.6.2.2 The interior of battery boxes should be unclassified provided they are adequately ventilated in accordance with Section 6.3.2.4.

Note: The method of ventilation must be carefully considered since some methods of ventilation may affect the classification of the area in which the battery boxes are installed.

8.2.6.6.2.3 The interior of battery boxes should be Division 2 provided: (a) the battery boxes have vent(s) with a cross-sectional area of less than 6.45 square centimeters (1 square inch) but not less than 3.23 square centimeters (0.5 square inch) for every 0.14 cubic meters (5 cubic feet) of battery box volume, (b) the vent(s) is not more than 45 degrees from vertical for



Notes:

1. The operating envelope and stored position of the outboard flange connection of the loading arm (or hose) should be considered the "source of release".

2. The berth area adjacent to tanker and barge cargo tanks is to be Zone 2 to the following extent:
   a. 7.5 meters(25 feet) horizontally in all directions on the pier side from that portion of the hull containing cargo tanks,
   b. From the water level to 7.5 meters (25 feet) above the cargo tanks at their highest position.

3. Additional locations may have to be classified as required by the presence of other sources of flammable liquids on the berth, or by the requirements of the Coast Guard or other authorities having jurisdiction.

Figure 19—Marine Terminal Handling Flammable Liquids
(See Section 8.2.4)

any point except wall penetrations, and (c) the vent(s) extends from the highest point of the battery box.

8.2.6.6.2.4 The interior of inadequately ventilated battery boxes not meeting the provisions of 8.2.6.6.2.1, 8.2.6.6.2.2, or 8.2.6.6.2.3 should be classified Zone 1.

Note: A Zone 0 or Zone 1 classification normally would prohibit the installation of batteries in the area. Check applicable requirements.

8.2.6.7 An enclosed, adequately ventilated location (excluding battery boxes, as provided for in 8.2.6.6.2) containing batteries is classified as follows:

8.2.6.7.1 Unclassified provided (1) calculations verify that natural ventilation will prevent the accumulation in the enclosed location of hydrogen above 25% of its LFL during normal float charge operations, and (2) the battery charging system is designed to prevent inadvertent overcharging.

8.2.6.7.2 Unclassified provided (1) calculations verify that mechanical ventilation will prevent the accumulation in the enclosed location of hydrogen above 25% of its LFL during normal float charge operations, (2) the battery charging system is designed to prevent inadvertent overcharging, and (3) effective safeguards against ventilation failure are provided.

Note: Ventilation rates should be based on the maximum hydrogen evolution rate for the applicable batteries. The maximum hydrogen evolution rate for lead antimony batteries should be considered as 0.000269 cubic feet per minute per charging ampere per cell at 25°C, with the maximum charging current available from the battery charger applied into a fully charged battery. The maximum hydrogen evolution rate for other types of batteries (e.g., lead calcium and nickel cadmium) should be obtained for the condition when the maximum charging current available from the battery charger is applied into a fully charged battery.

8.2.6.8 An enclosed, inadequately ventilated area containing batteries is classified as follows:

8.2.6.8.1 Zone 2 provided (a) ventilation is at least 25 per cent that required for adequate ventilation, and (b) the battery charging system is designed to prevent inadvertent overcharging.

8.2.6.8.2 Zone 1 if the criteria specified by 8.2.6.8.1 is not met.

Note: A Zone 0 classification normally would prohibit the installation of batteries in the area. Check applicable requirements.

8.2.7 Flammable and Combustible Paint Products—Storage and Usage Areas

8.2.7.1 General

8.2.7.1.1 This section addresses only the electrical classification of locations where flammable and combustible paint products (for example, paints, lacquers, and paint solvents) are stored or used. It does not address safe practices for the storage or use of these products, a subject outside the scope of this document.

8.2.7.1.2 This section does not cover rooms and other areas specifically intended for spray painting and similar operations where flammable and combustible paint products are regularly or frequently applied during normal operations in the room or area. These areas are not unique to petroleum facilities and are adequately addressed in Article 516 of the National Electrical Code, to which the reader should refer. Due to the wide variety of conditions and application methods encountered, this section does not cover painting operations, which are not unique to petroleum facilities.

8.2.7.2 Storage Areas

8.2.7.2.1 This sub-section covers non-enclosed and enclosed areas (e.g., rooms, cabinets, and lockers) where flammable and combustible paint products are stored.

8.2.7.2.2 This sub-section does not cover areas where paint brushes are cleaned with flammable solvents, paint is mixed with solvents, and other similar operations or areas where cleaning rags containing solvents, open containers of paint products, and similar materials are present. Where such operations are performed or such materials are present, reference 8.2.7.3.

8.2.7.2.3 Nonenclosed and enclosed, adequately ventilated and inadequately ventilated, areas where flammable and combustible paint products are stored in sealed containers (original containers or equivalent) are unclassified.

8.2.7.3 Usage Areas

8.2.7.3.1 This section covers areas where flammable and combustible paint products are used. "Used" is defined as operations such as cleaning paint brushes with flammable solvents and mixing paint with solvents where volatile gases or vapors will be given off to the atmosphere. Also included as "usage areas" are areas where cleaning rags containing solvents or open containers of paint products are present.

8.2.7.3.2 Most operations involving the use of paint products as described in the paragraph above are performed at random locations on an infrequent basis. Unless an area is specifically designated for such usage, it is impossible to assign area classification. This does not preclude the necessity of following safe practices in these areas during such usage, but the subject is outside the scope of this document. If an area is specifically designated for such usage, the area should be classified as follows:

8.2.7.3.3 Nonenclosed, adequately ventilated areas where flammable and combustible paint products are used are unclassified.

8.2.7.3.4 Adequately ventilated enclosed areas where flammable and combustible paint products are used are clas-

sified Zone 2 to the extent of the area except as specified in 8.2.7.3.4.1 and 8.2.7.3.4.2.

8.2.7.3.4.1 Adequately ventilated enclosed areas where flammable and combustible paint products are used are unclassified if the quantities of open containers of paint are 20 liters (five gallons) or less or if the quantities of open containers of solvent are four liters (one gallon) or less.

8.2.7.3.4.2 Adequately ventilated enclosed areas where only combustible paint products are used are unclassified if the temperature is below their flashpoints.

8.2.7.3.5 Inadequately ventilated enclosed areas where flammable or combustible paint products are used are classified Zone 1 to the extent of the area.

9 Recommendations for Determining Degree and Extent of Classified Locations in Petroleum Refineries

9.1 INTRODUCTION

9.1.1 This section presents guidelines for classifying locations for electrical installations at refinery facilities. The guidelines cover onshore refinery facilities handling flammable and combustible liquids and flammable gases and vapors.

9.1.2 The following recommendations for determining the degree and extent of classified locations have been developed by survey and analysis of the practices of a large segment of the petroleum refining industry, by use of available experimental data, and by careful weighing of pertinent factors such as the number of potential sources, the release rate and the volume of possible release. These recommended limits of classified locations for refinery installations may be more restrictive than are warranted for non-refining types of facilities handling hydrocarbons. In this sense, the recommendations are considered conservative.

9.1.3 Refinery processing facilities consist of specialized equipment within which liquids, gases, or vapors are continuously processed at high rates and at elevated temperatures and pressures. Both chemical and physical changes occur in these materials, and during abnormal conditions the composition and properties of stocks may change drastically. These conditions, together with considerations of operating continuity, dictate standards of refinery design that may not be warranted in other petroleum industry operations. However, although these recommendations are applicable primarily to refinery areas, it is recognized that a modern refinery includes facilities other than those traditionally associated with refining operations. Often petrochemical and chemical facilities are interrelated both physically and by process procedure with refining equipment. The practices recommended in this section can be applied to these additional facilities to the extent that such physical relationships or process similarities exist.

9.1.4 In setting limits of classified locations in refinery facilities, it generally is assumed that the flammable gases and vapors are heavier-than-air. Classification on this basis is normally conservative for lighter-than-air gases such as hydrogen. However, some modification of the limits may be necessary to accommodate certain situations involving lighter-than-air gases.

9.1.5 Experience has shown that the occurrence of flammable material liberation from some operations and apparatus is so infrequent that it is not necessary to classify the surrounding areas. An example of such an area is an adequately ventilated location where flammable substances are contained in suitable, well maintained closed piping systems that include only the pipe, fittings, flanges, meters, and small valves.

9.1.6 The diagrams in Section 9.2 show classified locations surrounding typical sources of flammable liquids, vapors and gases. The intended use of these diagrams is to develop area classification documentation used for the selection of and proper installation methods for electrical equipment. Area classification drawings or other documentation may be required by certain regulatory agencies. Elevations or sections may also be required where different classifications apply at different elevations.

9.1.7 It may be found that individual classification of a great number of sources in a location is not feasible or desirable. Classification of an entire location as a single area should be considered after evaluation of the extent and interaction of various sources and areas within, or adjacent to, the location.

9.1.8 Documentation should include the Class and Group of each source or area and the extent of the

9.1.9 Zone 0, Zone 1, and Zone 2 locations. A method, such as unique cross hatching, should be used to identify the extent of each location. Reference Section E.6 in Appendix E and Appendix C.

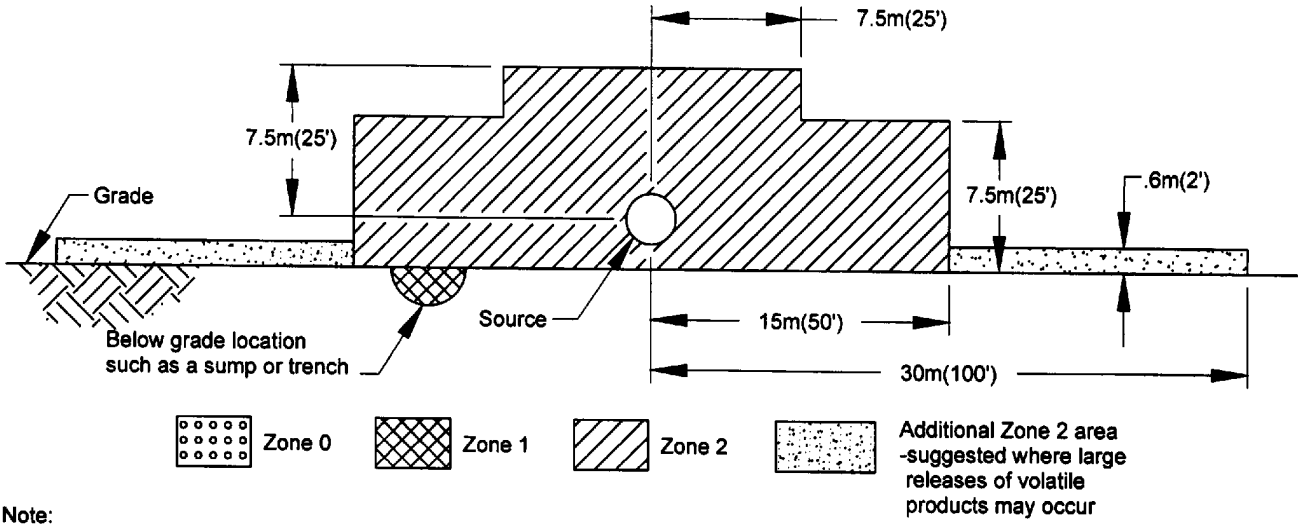
9.2 RECOMMENDATIONS

9.2.1 Locations where heavier-than-air flammable gases are handled or stored should be classified in accordance with 9.2.1.1 and 9.2.1.2.

9.2.1.1 Within adequately ventilated locations containing closed systems, refer to Figures 20 and 21.

Note: Manholes and interconnecting raceways may collect flammable liquids or gases that can then be conducted to other locations unless prevented by proper sealing, purging, water flooding, or other methods.

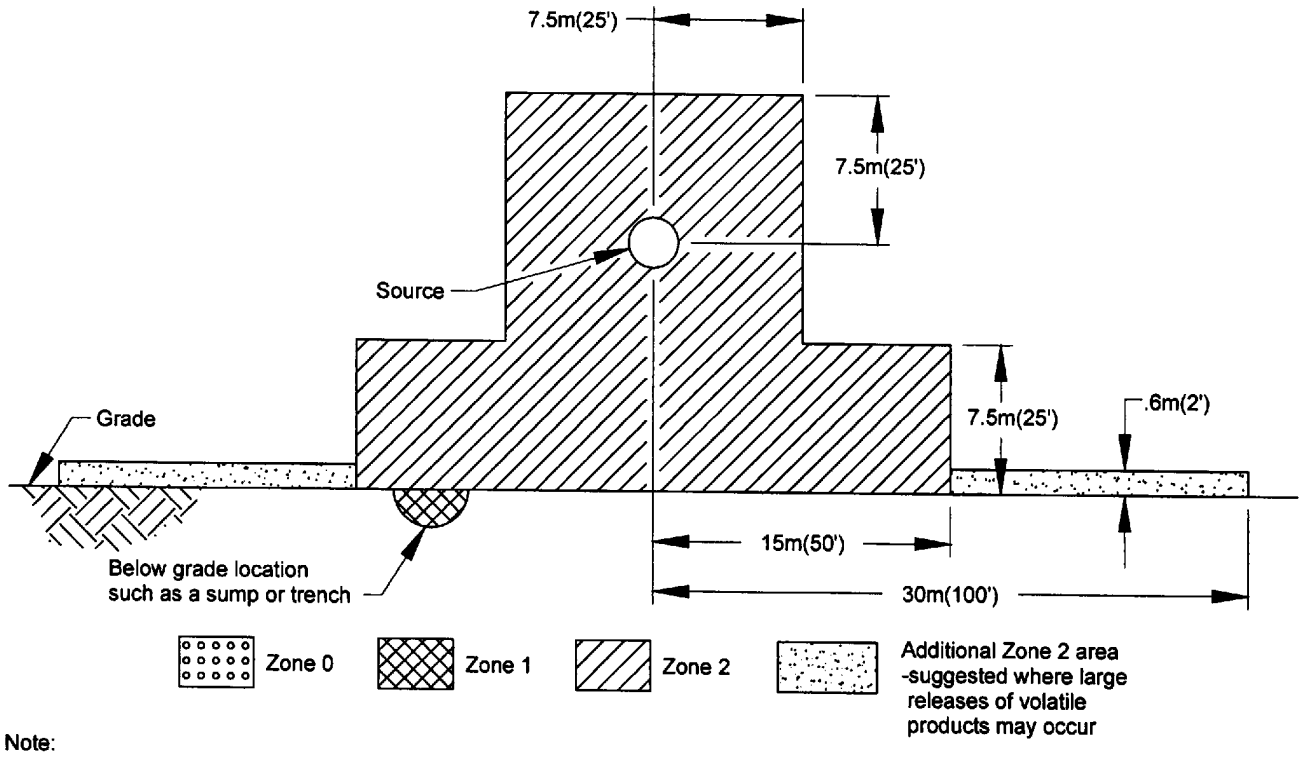
9.2.1.2 Within inadequately ventilated locations containing closed systems, refer to Figure 22.



Note:

Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

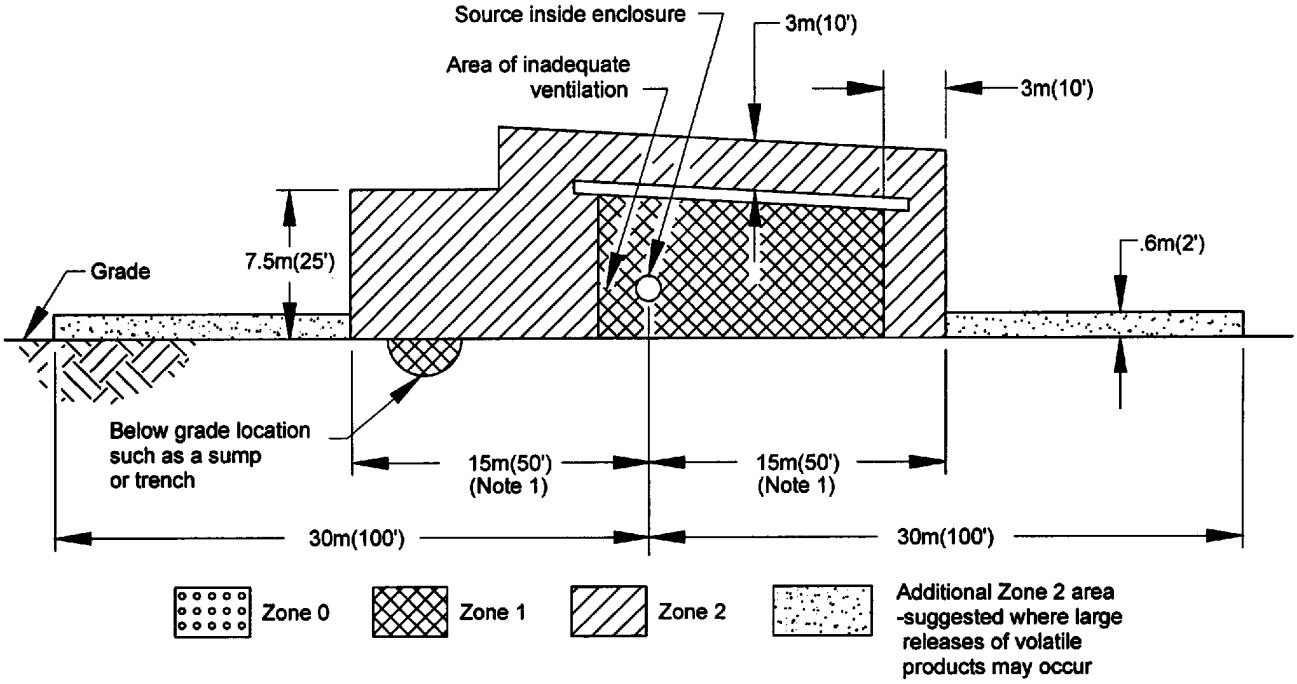
Figure 20—Adequately Ventilated Process Location With Heavier Than-Air-Gas or Vapor Source Located Near Grade
(See Section 9.2.1.1)



Note:

Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 21—Adequately Ventilated Process Location With Heavier-Than-Air Gas or Vapor Source Located Above Grade
(See Section 9.2.1.1)



Notes:

1. Apply horizontal distances of 15 meters (50 feet) from the source of gas or vapor or 3 meters (10') beyond the perimeter of the building, whichever is greater, except that beyond unpierced vaportight walls the area is unclassified.
2. Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

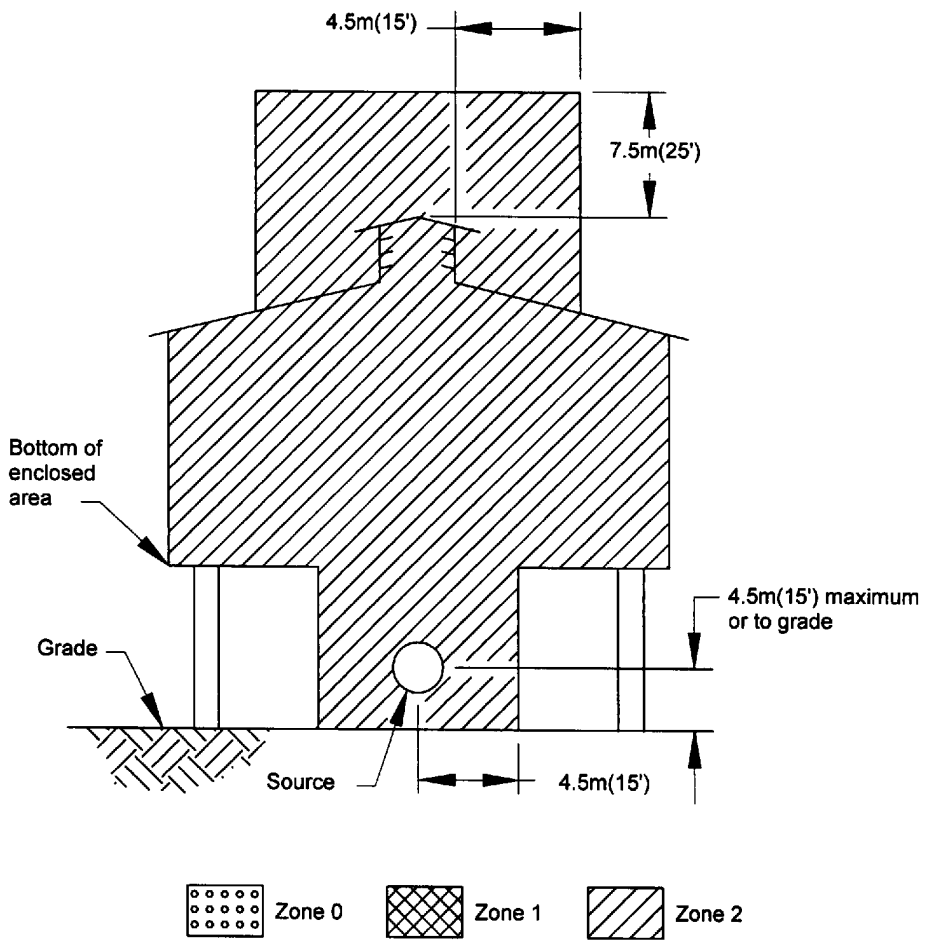
Figure 22—Inadequately Ventilated Process Location With Heavier-Than-Air Gas or Vapor Source (See Section 9.2.1.2)

9.2.2 Locations where lighter-than-air flammable gases or vapors are handled should be classified in accordance with 9.2.2.1 and 9.2.2.2.

9.2.2.1 Within adequately ventilated locations containing closed systems, refer to Figures 23 and 24.

9.2.2.2 Within inadequately ventilated refinery process areas containing closed systems, refer to Figures 25 and 26.

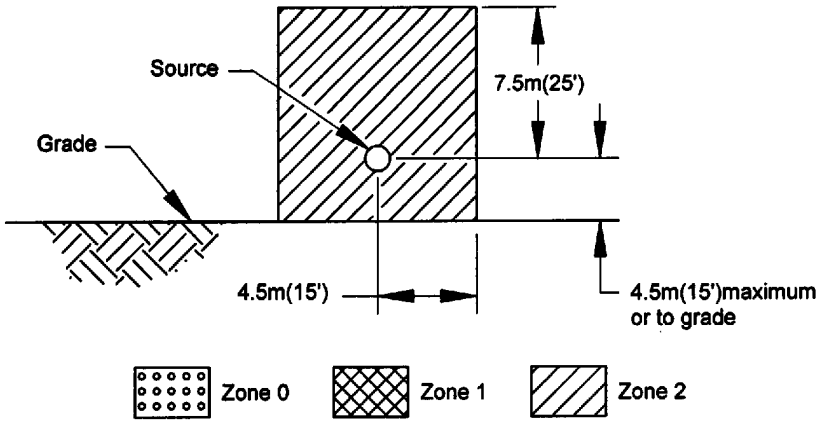
9.2.3 In separators, dissolved air flotation units, and biological oxidation units, refer to Figure 27.



Note:

Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

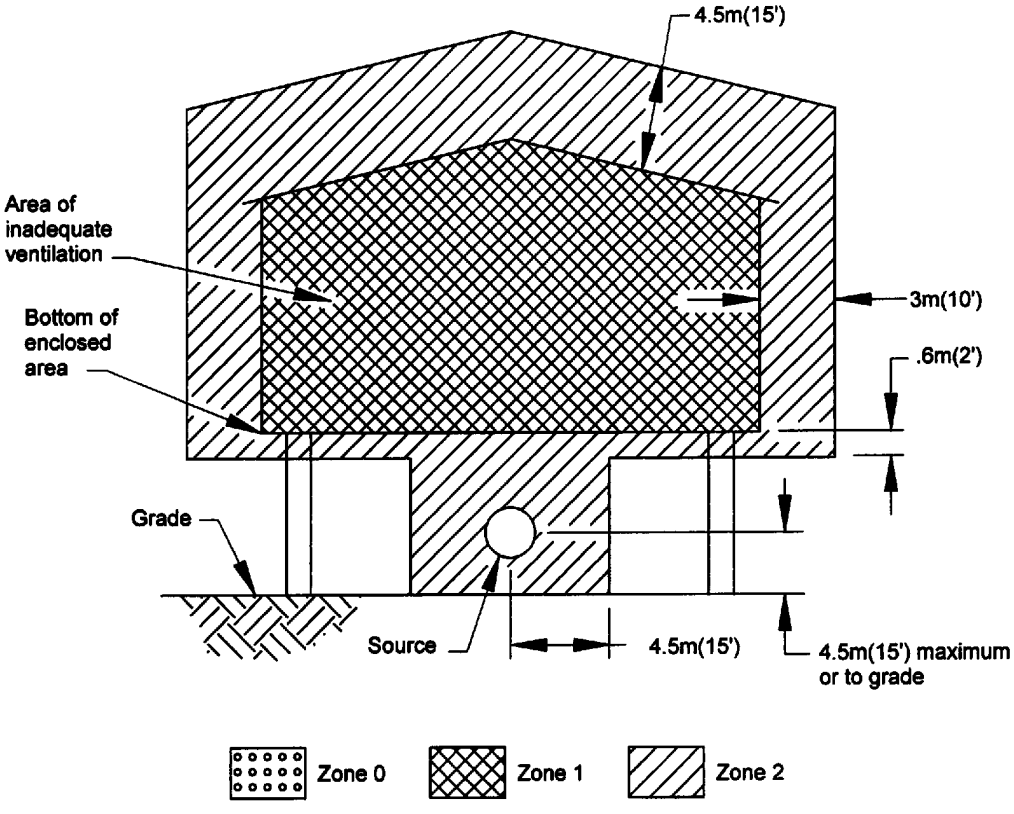
Figure 23—Adequately Ventilated Compressor Shelter With Lighter-Than-Air Gas or Vapor Source (See Section 9.2.2.1)



Note:

Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 24—Adequately Ventilated Process Location With Lighter-Than-Air Gas or Vapor Source (See Section 9.2.2.1)



Note:

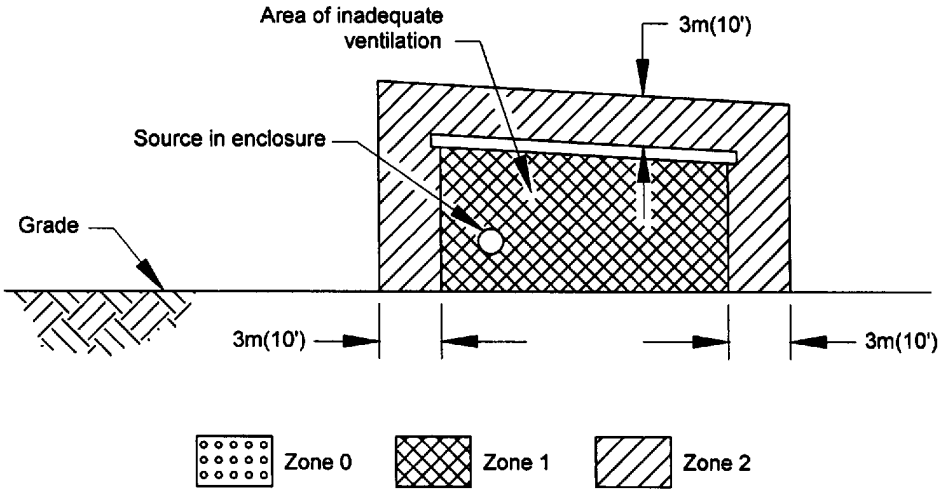
Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

Figure 25—Inadequately Ventilated Compressor Shelter With Lighter-Than-Air Gas or Vapor Source (See Section 9.2.2.2)

9.2.4 In cooling towers, refer to Figure 28.

9.2.4.1 Cooling tower pump pits located in unclassified locations need not be classified since cooling tower pumps are not considered sources of release.

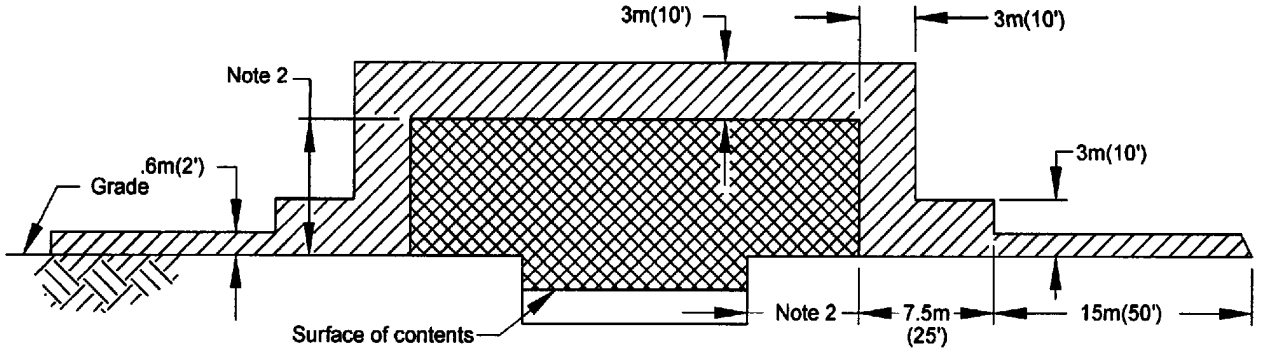
9.2.5 For marine terminals handling flammable liquids, refer to Figure 19.



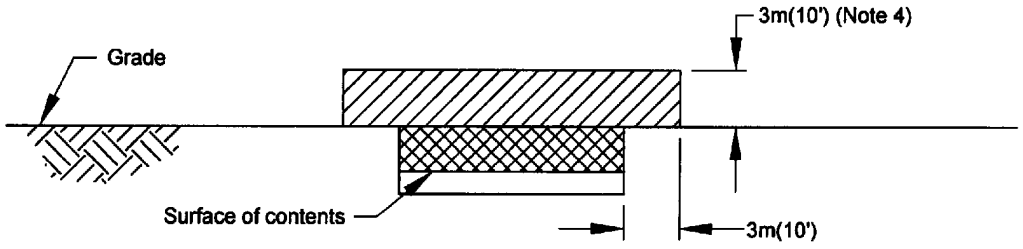
Note:

Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all factors discussed in the text. In some instances, greater or lesser distances may be justified.

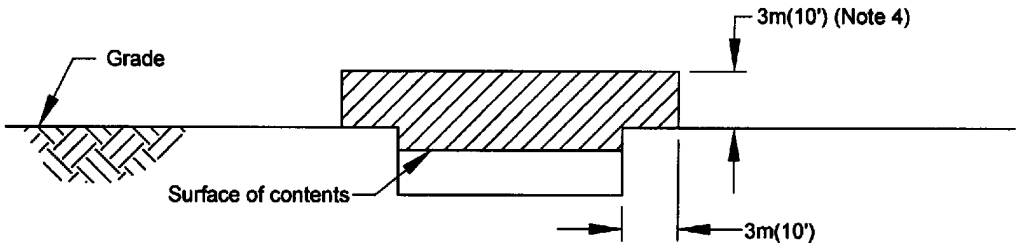
Figure 26—Inadequately Ventilated Process Location With Lighter-Than-Air Gas or Vapor Source (See Section 9.2.2.2)



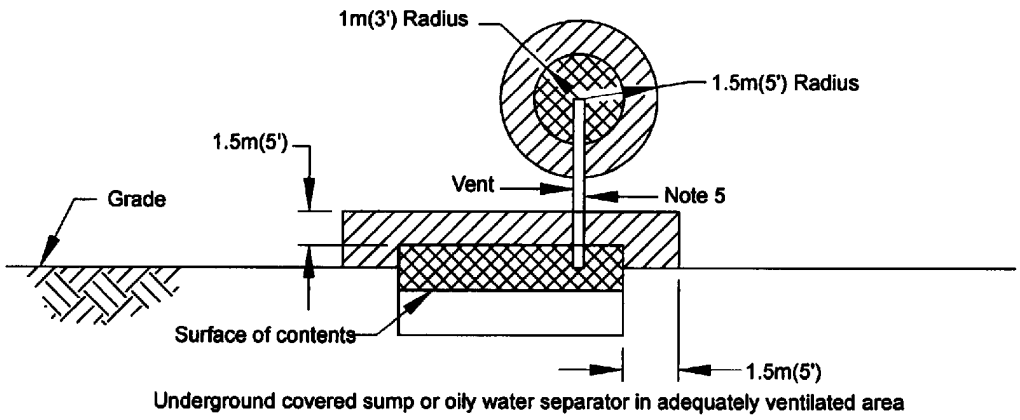
Unit separators, preseparators, and separators (Note 3)



Dissolved air flotation (DAF) units (Note 3)



Biological oxidation (BIOX) units

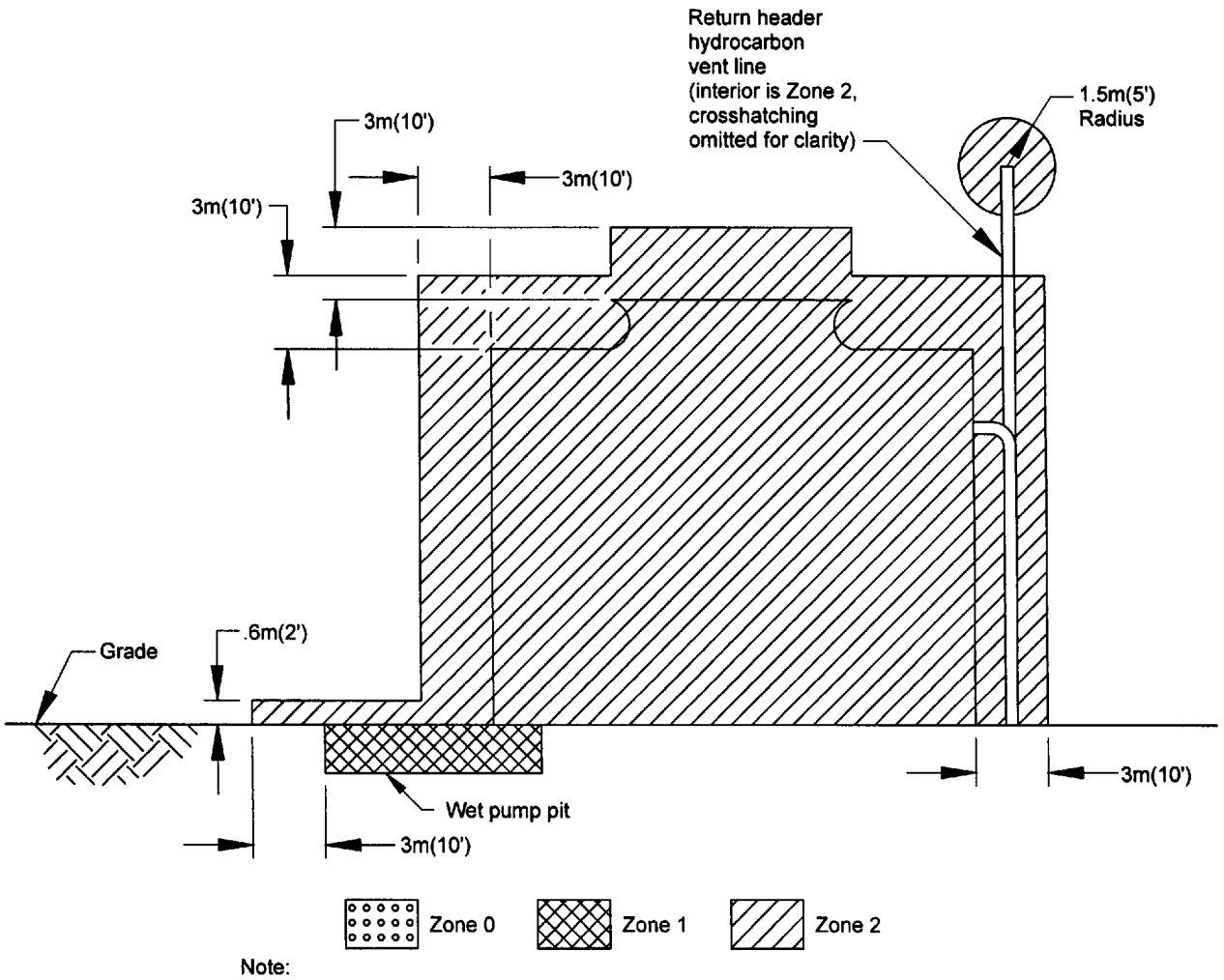


Underground covered sump or oily water separator in adequately ventilated area

Notes: Zone 0 Zone 1 Zone 2

1. The extent of the classified areas shown shall be modified as required by the proximity of other potential sources of release or of nearby obstructions, such as dikes or hills, that would impede dispersal of vapors. Distances given are for typical refinery installations: they must be used with judgement, with consideration given to all the factors discussed in the text. In some instances, greater or lesser distances may be justified.
2. This dimension usually varies from 3 meters (10 feet) to 7.5 meters (25 feet) dependent on the volume of the volatiles.
3. Applies to open top tanks or basins. Classify closed tank units per figure 6.
4. Distances above top of basin or tank. Extend to grade for basins or tanks located above grade.
5. The interior of the vent piping is Zone 1. Cross hatching has been omitted for clarity.

Figure 27—Separators, Dissolved Air Flotation (DAF) Units, and Biological Oxidation (BIOX) Units (See Section 9.2.3)



Note:

It is recommended that electrical equipment be located away from the vent area.

Figure 28—Mechanical Draft Cooling Tower Handling Process Cooling Water
(See Section 9.2.4)

10 Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Land and on Marine Fixed Platforms

10.1 GENERAL

10.1.1 This section presents guidelines for classifying locations for electrical installations at locations surrounding oil and gas drilling and workover rigs and facilities on land and on marine fixed and mobile platforms where flammable petroleum gas and volatile liquids are produced, processed, stored, transferred, or otherwise handled prior to entering the transportation facilities.

10.1.2 The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered in producing and drilling operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing material presented in this recommended practice and other publications. Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.

10.1.3 High pressures, potentially large releases, and the presence of HVLs may justify greater dimensions for classified locations than those shown.

10.2 DRILLING AREAS

Drilling areas considered for classification by this section include the following:

a. Rig floor and substructure area
b. Mud tank
c. Mud ditch, trench, or pit
d. Mud pump
e. Shale shaker
f. Desander or desilter
g. Degasser
h. Diverter line vent
i. Blowout Preventer (BOP)

10.3 PRODUCTION FACILITIES

Production facilities considered for classification by this section include the following:

a. Producing oil and gas wells
   1. Flowing wells
   2. Artificially lifted wells
      a. Beam pumping wells
      b. Mechanically driven, rotating, subsurface pumps
      c. Electric submersible pumping wells
      d. Hydraulic subsurface pumping wells
      e. Gas lift wells
      f. Plunger lift wells
   3. Multi-well installations
b. Oil and gas processing and storage equipment
   1. Hydrocarbon pressure vessel
   2. Header or manifold
   3. Fired equipment
   4. Launcher or receiver
      a. Ball or pig launcher or receiver
      b. Through flow line (TFL) tool launcher or receiver
   5. Dehydrator, stabilizer, and hydrocarbon recovery unit
   6. Automatic custody transfer (ACT) unit
   7. Flammable gas-blanketed and produced water handling equipment
   8. Gas compressor or pump handling volatile, flammable fluids
   9. Instruments
      a. Not operated by flammable gas
      b. Operated by flammable gas
   10. Sumps
   11. Drains
   12. Screwed connections, flanges, valves and valve operators
   13. Drip pans
   14. Control panels

10.4 DRILLING WELLS

Areas surrounding wells being drilled or being serviced by drilling rigs are classified as follows:

10.4.1 Rig Floor and Substructure Area

10.4.1.1 When the derrick is not enclosed or is equipped with a "windbreak" (open top and open "V" door) and the substructure is adequately ventilated, the areas are classified as shown in Figure 29.

Note 1: Derricks enclosed with a windbreak (open top and open V door) such as that depicted by Figure 29 are considered to satisfy the requirements of adequate ventilation through years of satisfactory experience with this practice.

Note 2: An open substructure such as that depicted by Figure 29 is classified Zone 2 for 3 meters (10 feet) from the center of the wellbore because of well testing, well completion, and workover operations.

10.4.1.2 When the derrick is enclosed (open top) with adequate ventilation and the substructure is inadequately ventilated, the areas are classified as shown in Figure 30.

Note: The enclosed substructure depicted by Figure 30 is classified Zone 1 because it contains the bell nipple, which can allow release of flammable gas during normal operations. The area above the top of the derrick enclosure is classified as Zone 2 as it is considered a vent.

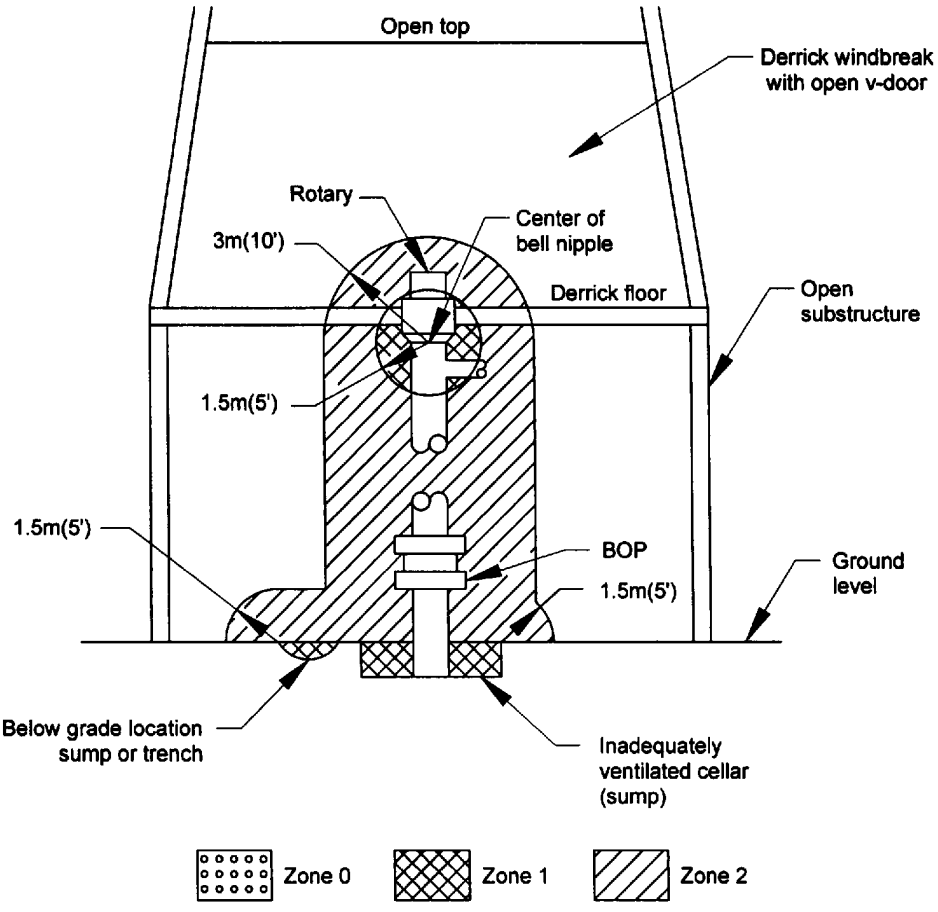


Figure 29—Drilling Rig, Adequate Ventilation in Substructure, and Derrick is Not Enclosed, But is Equipped With a Windbreak, Open Top, and Open V-Door
(See Section 10.4.1.1.)

10.4.1.3 For drilling rigs on offshore platforms with producing wells in an adequately ventilated location below the platform drilling deck, the locations are classified as shown in Figure 31. Reference Figure 29 or 30 for classification of the drilling rig; the specific rig shown is as described by Section 10.4.1.1.

10.4.1.3.1 For drilling rigs on offshore platforms with producing wells in an inadequately ventilated location below the platform drilling deck, the areas are classified as shown in Figure 32. Reference Figure 29 or 30 for classification of the drilling rig; the specific rig shown is as described by Section 10.4.1.1.

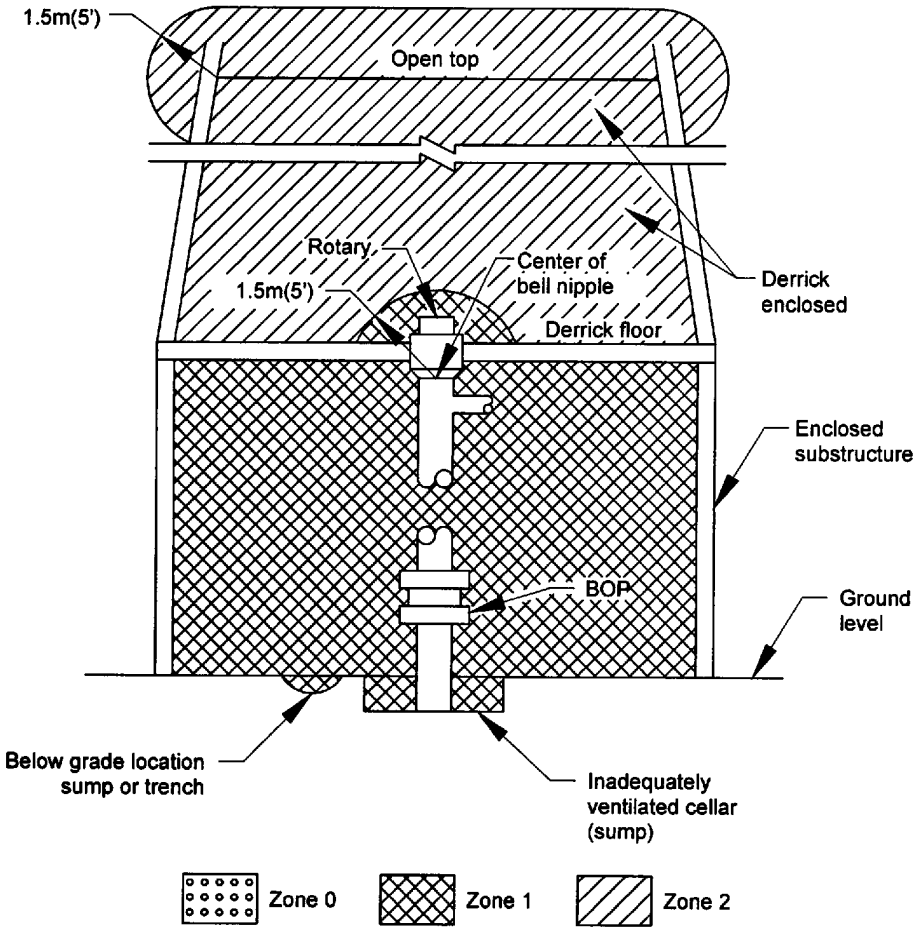


Figure 30—Drilling Rig, Adequate Ventilation in Enclosed Derrick (Open Top), and Inadequately Ventilated Substructure
(See Section 10.4.1.2.)

10.4.2 Mud Tank

10.4.2.1 The area around a mud tank located in a nonenclosed adequately ventilated location is classified to the extent shown in Figure 33.

10.4.2.2 The area around a mud tank located in an adequately ventilated enclosed area is classified as illustrated by Figure 33, but Zone 2 for the remainder of the extent of the enclosed area.

10.4.2.3 The area around a mud tank located in an enclosed inadequately ventilated location is classified to the extent shown in Figure 34.

10.4.3 Mud Ditch, Trench, or Pit

10.4.3.1 The area around an open ditch or trench used to connect between mud tanks and open active mud pits located in nonenclosed adequately ventilated areas is classified the same as illustrated for mud tanks in Figure 33.

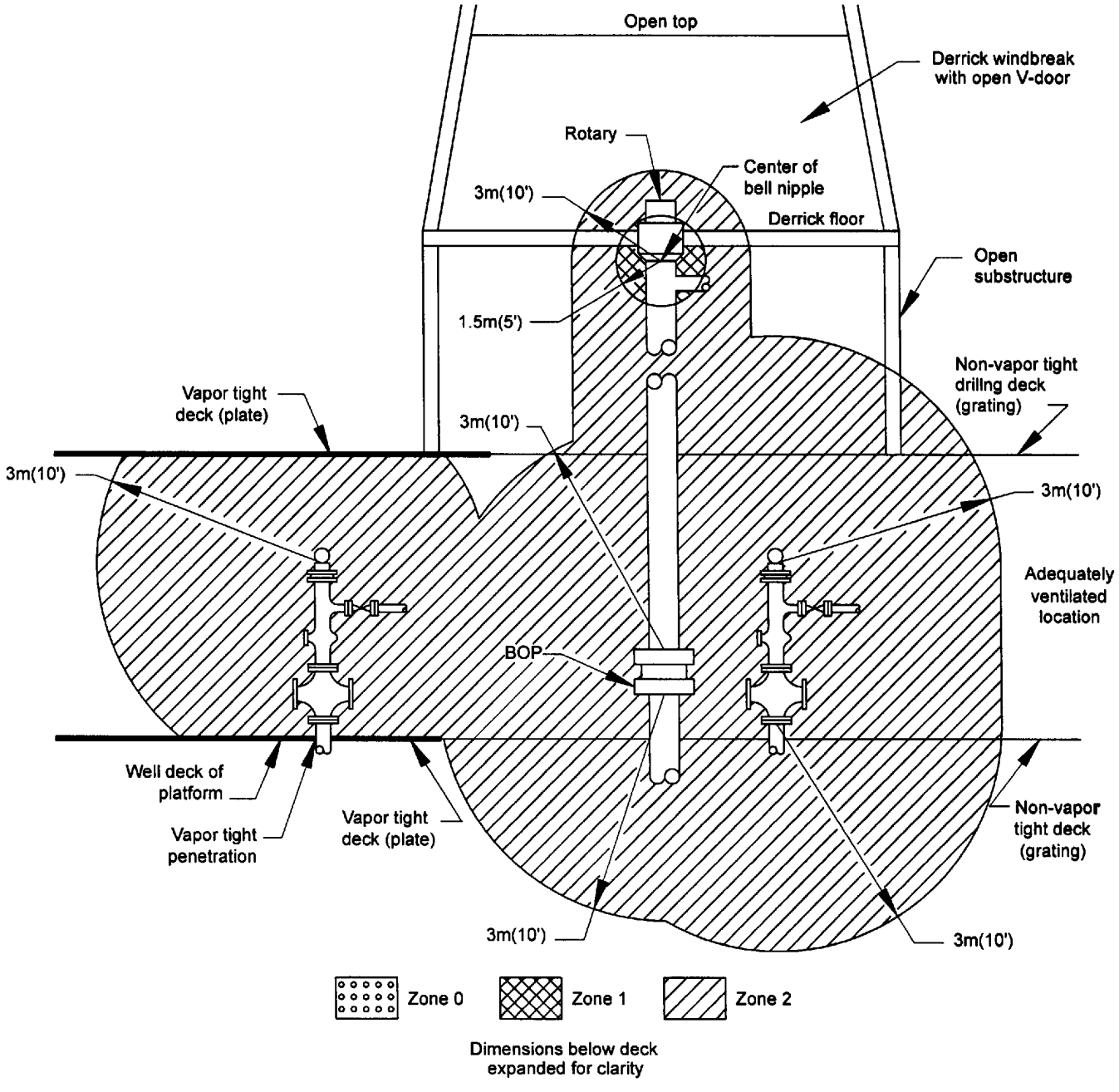


Figure 31—Platform Drilling Rig, Adequately Ventilated in Substructure and Inside Derrick, Several Producing Wells Beneath in an Adequately Ventilated Area
(See Section 10.4.1.2.)

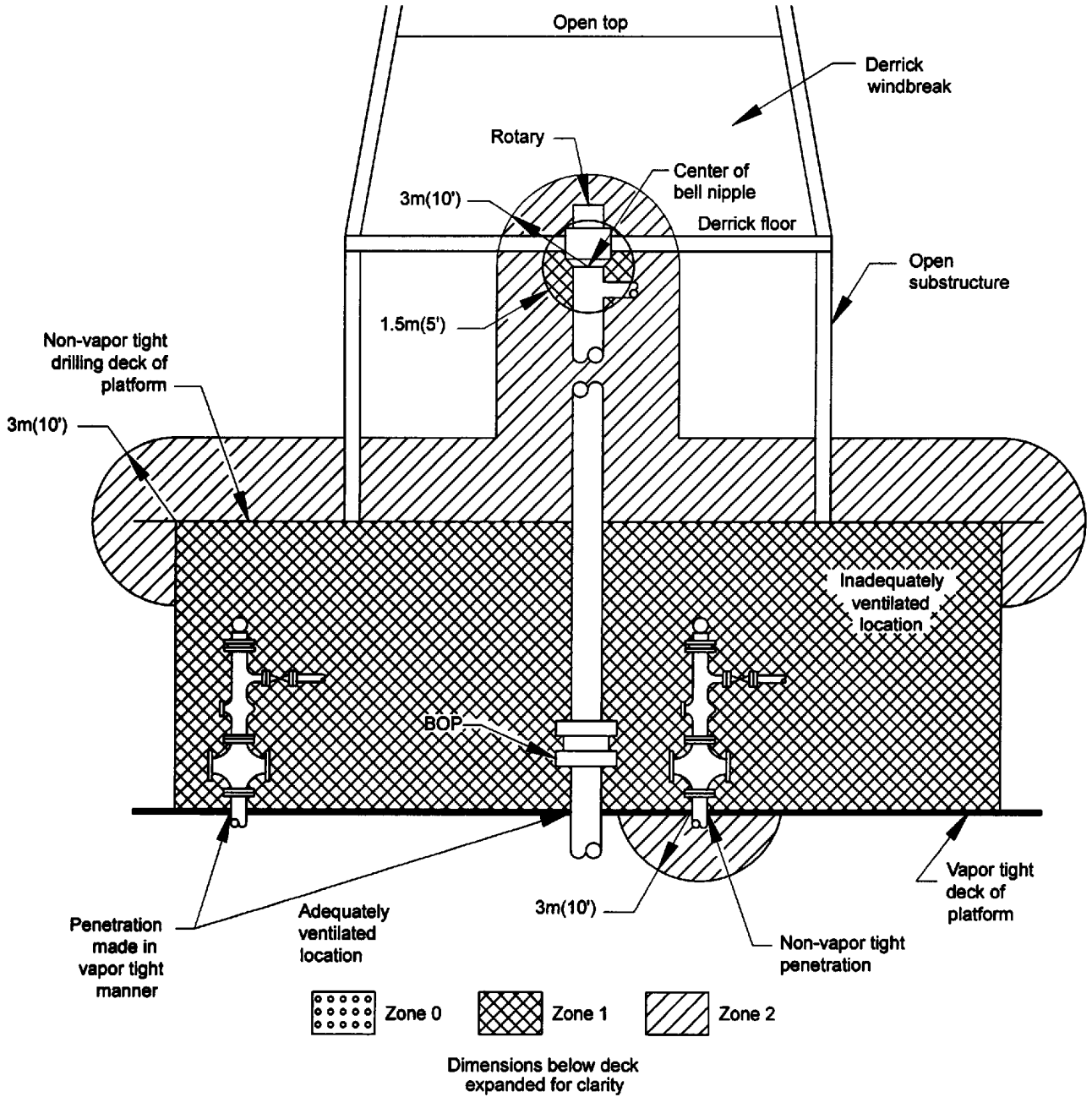


Figure 32—Platform Drilling Rig, Adequate Ventilation in Substructure and Inside Derrick, Several Producing Wells Beneath in an Inadequately Ventilated Location
(See Sections 10.4.1.4 and 10.5.1.4.)

10.4.3.2 The area around an open ditch or trench used to connect between mud tanks and open, active mud pits located in adequately ventilated enclosed areas is classified the same as illustrated for mud tanks in Figure 33, but Zone 2 for the remainder of the extent of the enclosed area.

10.4.3.3 The area around an open ditch or trench used to connect between mud tanks and open, active mud pits located in inadequately ventilated areas is classified the same as illustrated for mud tanks in Figure 34.

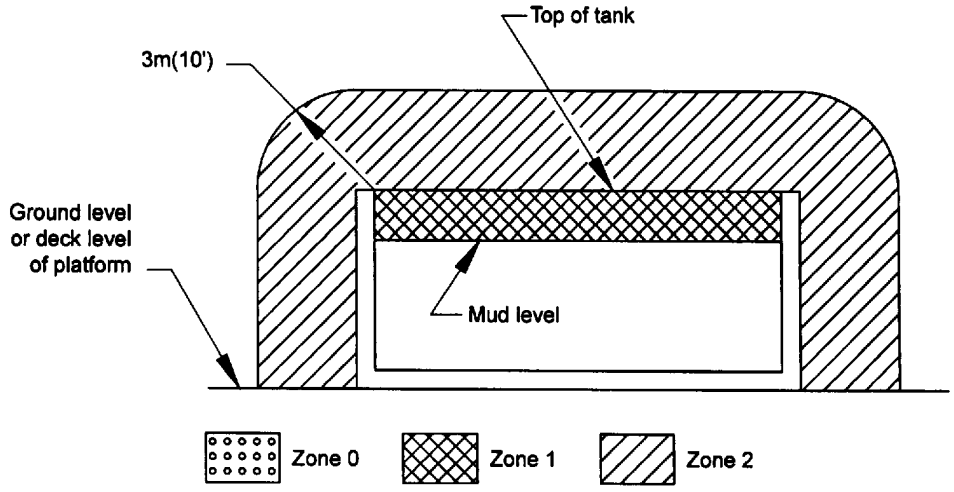


Figure 33—Mud Tank in a Nonenclosed Adequately Ventilated Area
(See Sections 10.4.2.1,10.4.3.1, and 10.12.2.)

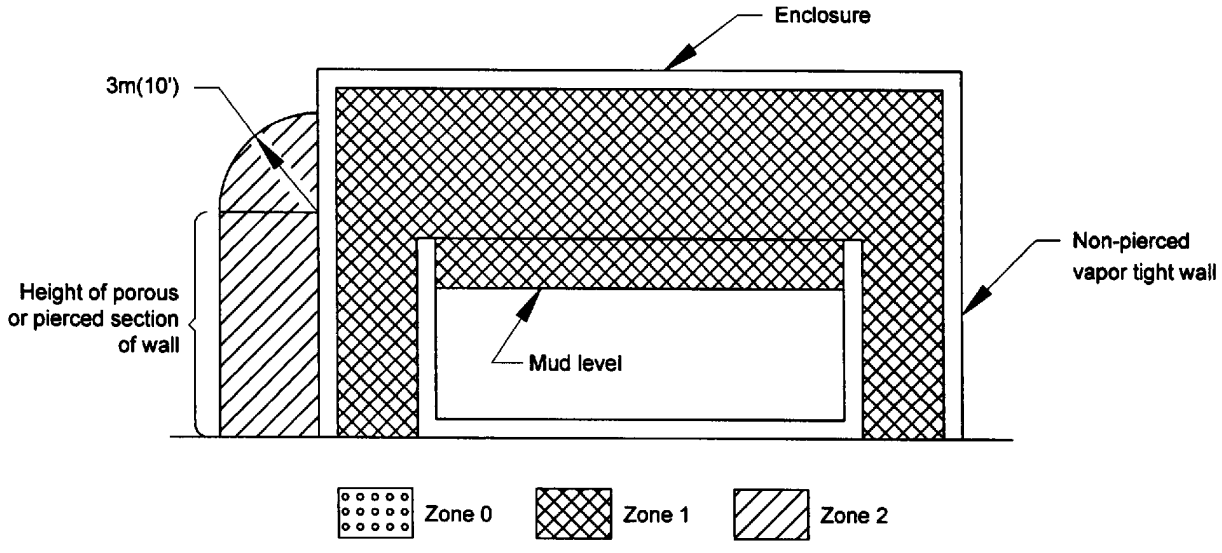


Figure 34—Mud Tank in an Enclosed Inadequately Ventilated Area
(See Sections 10.4.2.3, 10.4.3.3, and 10.12.3)

10.4.4 Mud Pump

10.4.4.1 The area surrounding a mud pump in a nonenclosed or enclosed adequately ventilated location is unclassified.

10.4.4.2 The area surrounding a mud pump in an inadequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.5 Shale Shaker

10.4.5.1 The location surrounding a shale shaker located in a nonenclosed adequately ventilated area is classified as shown in Figure 35.

10.4.5.2 The location surrounding a shale shaker located in an adequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

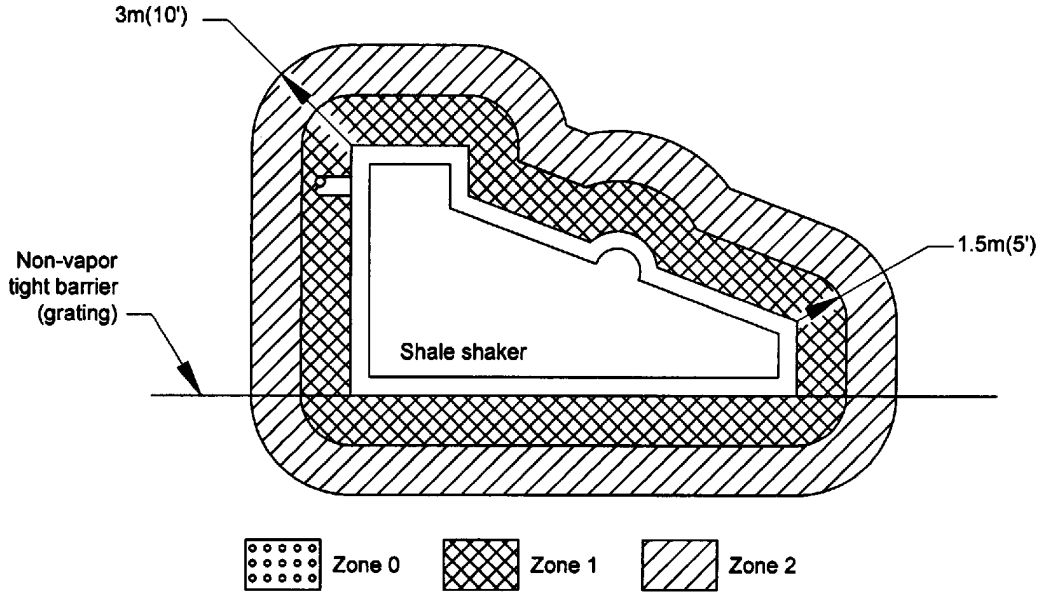


Figure 35—Shale Shaker in a Nonenclosed Adequately Ventilated Area (See Section 10.4.5.1)

10.4.5.3 The location surrounding a shale shaker located in an inadequately ventilated enclosed area is classified Zone 0 to the extent of the enclosed area.

10.4.6 Desander or Desilter

10.4.6.1 The location surrounding a desander or desilter located in a nonenclosed adequately ventilated location is classified as shown in Figure 36.

10.4.6.2 The location surrounding a desander or desilter located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area as in Figure 37.

10.4.6.3 The location surrounding a desander or desilter located in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.4.7 Degasser

10.4.7.1 The location surrounding a degasser located in a nonenclosed adequately ventilated location is unclassified.

10.4.7.2 The location surrounding a degasser located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

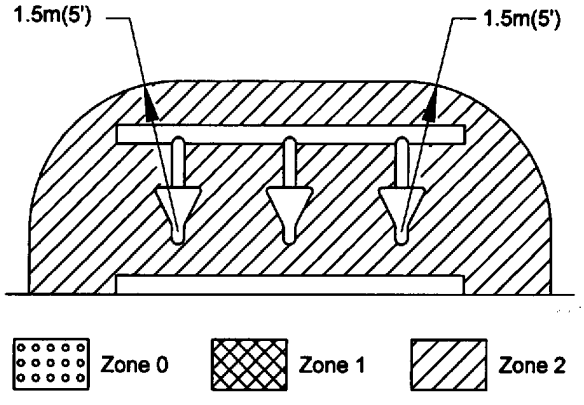


Figure 36—Desander or Desilter in a Nonenclosed Adequately Ventilated Area (See Section 10.4.6.1 and 10.4.7.1)

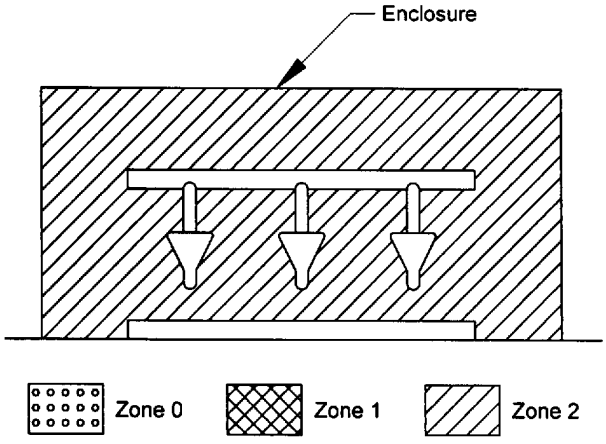
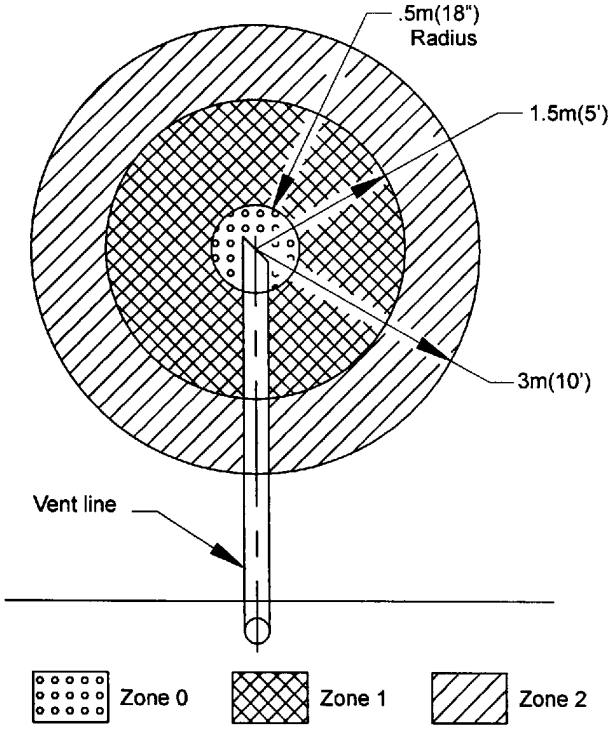


Figure 37—Desander or Desilter in an Adequately Ventilated Enclosed Area
(See Section 10.4.7.2)

10.4.7.3 The location surrounding a degasser located in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.4.7.4 The area surrounding the vent from a degasser is classified as shown in Figure 38.



Note:

The interior of the vent piping is Zone 0. Cross hatching has been omitted for drawing clarity.

Figure 38—Degasser Vent In Nonenclosed Adequately Ventilated Area
(See Section 10.4.7.4)

10.4.8 Blowout Preventer (BOP)

10.4.8.1 The area surrounding a BOP in a nonenclosed adequately ventilated location is classified Zone 2 for a distance of three meters (10 feet) from the centerline of the BOP.

10.4.8.2 The area surrounding a BOP in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.4.8.3 The area surrounding a BOP in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.5 PRODUCING OIL AND GAS WELLS

Areas adjacent to producing oil and gas wells are classified as, follows:

10.5.1 Flowing Well

10.5.1.1 The area around a flowing well located in a nonenclosed adequately ventilated location where a cellar or below grade sump is not present is classified as shown by Figure 39.

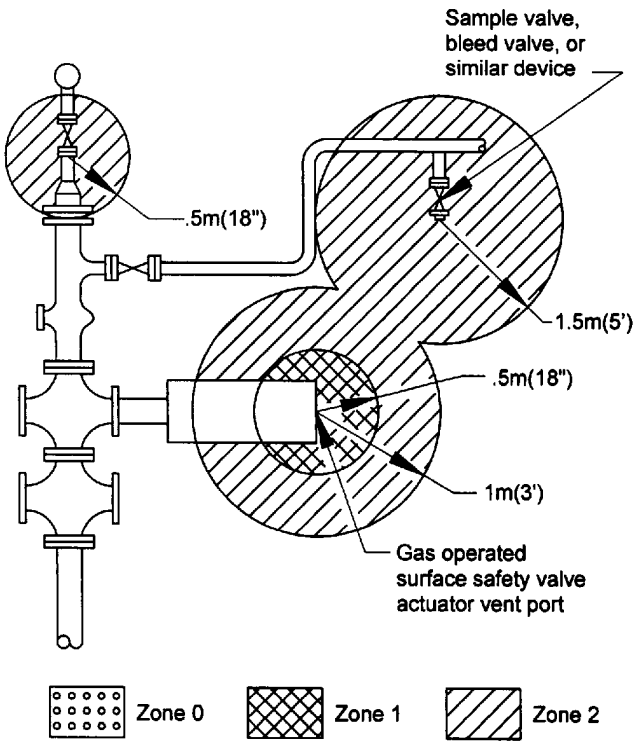


Figure 39—Flowing Well in a Nonenclosed Adequately Ventilated Area and Without a Cellar or Below Grade Sump
(See Section 10.5.1.1 and 10.15.3.2)

10.5.1.2 The area around a flowing well located in a nonenclosed adequately ventilated location with an inadequately ventilated cellar or below grade sump is Zone 1 below grade and Zone 2 above grade to the extent shown in Figure 40.

10.5.1.3 A flowing well located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.5.1.4 A flowing well located in an inadequately ventilated enclosed area (such as a wellhead room) is classified Zone 1 to the extent of the enclosed area as shown in Figures 32 and 41.

10.5.1.5 Surface Safety Valves. See Section 10.15.2, Process Control Valves.

10.5.1.6 Sample Valves, Instrument Drain Valves, Gauge Valves and Similar Devices. See Section 10.15.4, Sample Valves, Instrument Drain Valves, Gauge Valves, and Similar Devices.

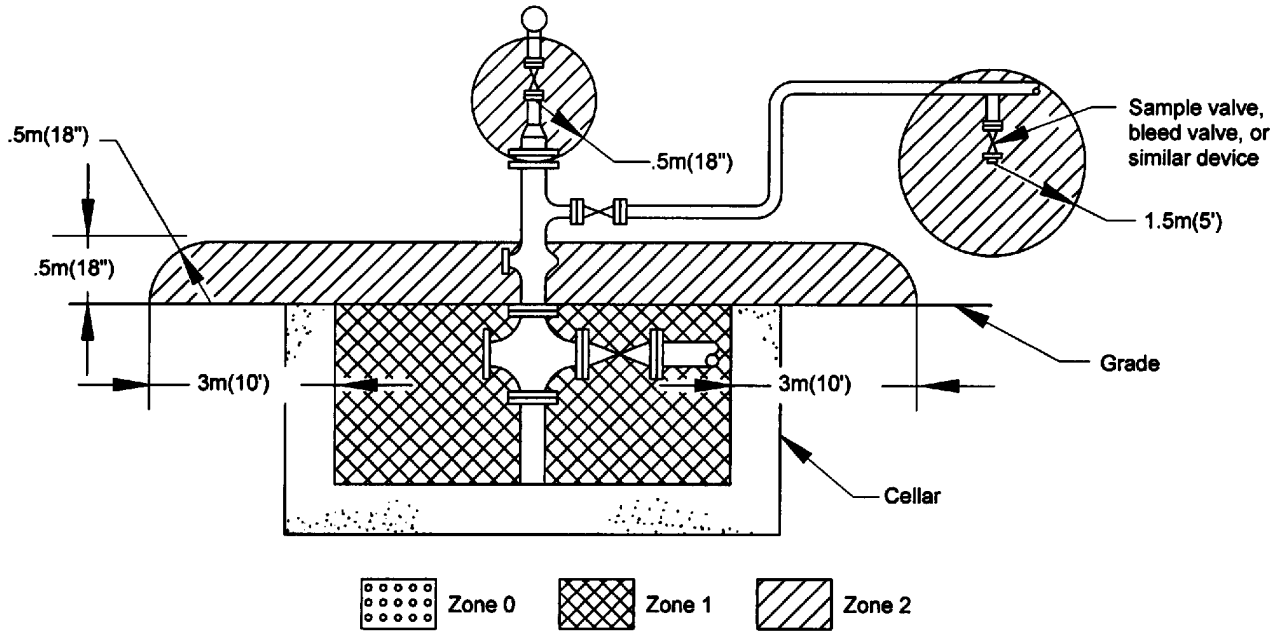


Figure 40—Flowing Well in a Nonenclosed Adequately Ventilated Area With an Inadequately Ventilated Cellar or Below Grade Sump
(See Section 10.5.1.2 and 10.15.3.2)

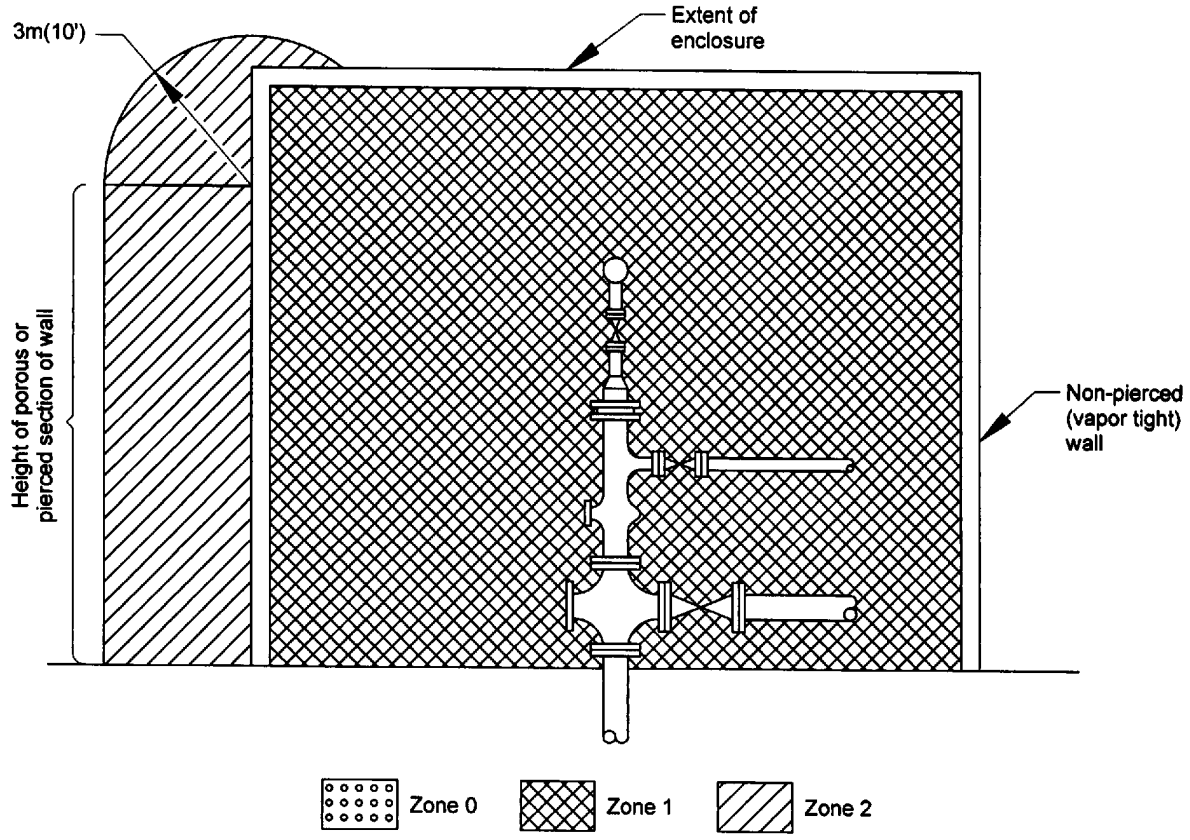


Figure 41—Flowing Well in an Inadequately Ventilated Enclosed Area (See Section 10.5.1.4)

10.5.1.7 Wireline Lubricator

10.5.1.7.1 The area around the stuffing box on a wireline lubricator in a nonenclosed adequately ventilated location is classified as shown in Figure 42.

10.5.1.7.2 The area around the stuffing box on a wireline lubricator in an adequately ventilated enclosed area is classified Zone 1 as shown by Figure 42 and Zone 2 for the remainder of the extent of the enclosed area.

10.5.1.7.3 The area around the stuffing box on a wireline lubricator in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.5.2 Artificially Lifted Wells

10.5.2.1 Beam Pumping Well

10.5.2.1.1 Where a cellar or below grade sump is not present, the area around a beam pumping well in a nonenclosed adequately ventilated area is Zone 2 to the extent shown in Figure 43.

10.5.2.1.2 The area around a beam pumping well in a nonenclosed adequately ventilated area where in inadequately ventilated cellar or below grade sump is present is classified Zone 1 below grade and Zone 2 above grade to the extent shown in Figure 44.

10.5.2.1.3 The area around a beam pumping well in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.5.2.1.4 The area around a beam pumping well in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.5.2.2 Mechanically Driven, Rotating, Subsurface Pumps. The location around a well produced with a downhole pump, shaft driven by a surface mounted prime mover, (e.g.,

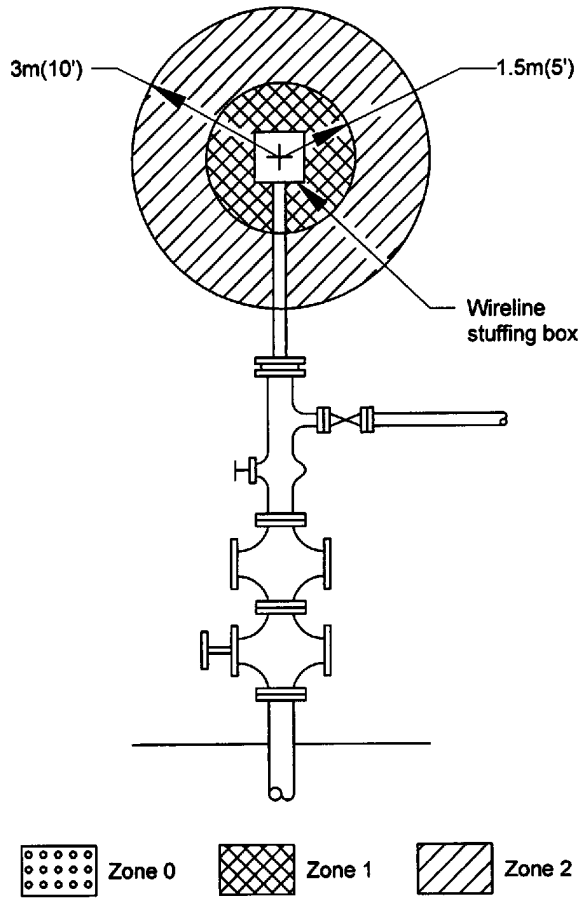


Figure 42—Nonenclosed Adequately Ventilated Well on Which Wireline Work is Being Performed (See Sections 10.5.1.7.1and 10.5.1.7.2)

progressive cavity pump) is classified the same as the location around a beam pumping well. Reference Section 10.5.2.1.

10.5.2.3 Electric Submersible Pumping Well

10.5.2.3.1 Where a cellar or below grade sump is not present, the area around an electric submersible pump wellhead in a nonenclosed, adequately ventilated location is classified Zone 2 to the extent shown in Figure 45.

10.5.2.3.2 Where an inadequately ventilated cellar or below grade sump is present at a well produced with an electric submersible pump, the location is classified as shown in Figure 46.

10.5.2.3.3 The area surrounding a junction box connected directly to an electric submersible pump by a cable or conduit in a nonenclosed adequately ventilated location is classified as shown in Figure 47.

10.5.2.3.3.1 The interior of the junction box is classified Zone 2 if vented.

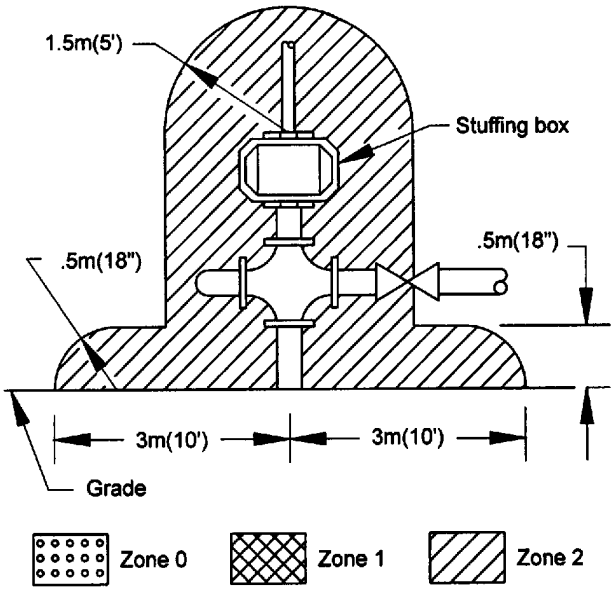


Figure 43—Nonenclosed Beam Pumping Well in an Adequately Ventilated Area Without a Cellar (See Section 10.5.2.1.1)

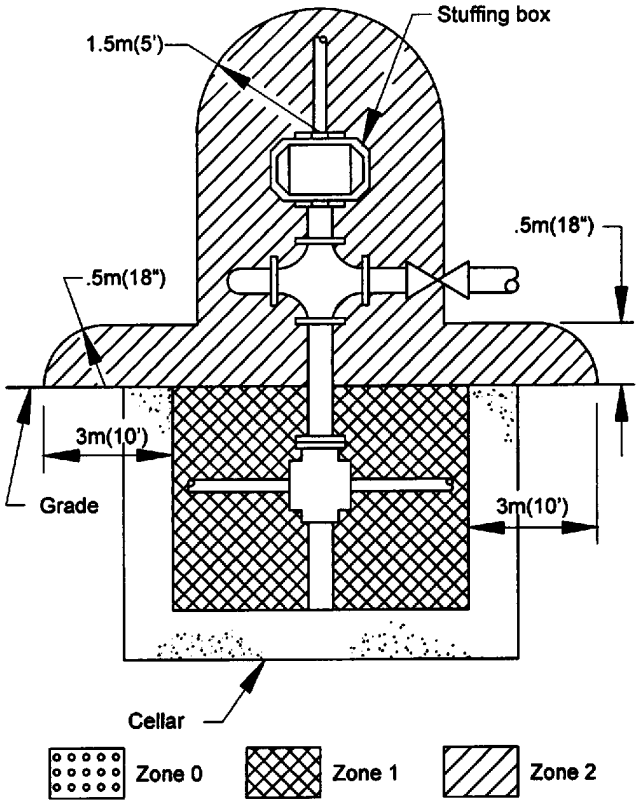


Figure 44—Nonenclosed Beam Pumping Well in an Adequately Ventilated Area With an Inadequately Ventilated Cellar (See Section 10.5.2.1.2)

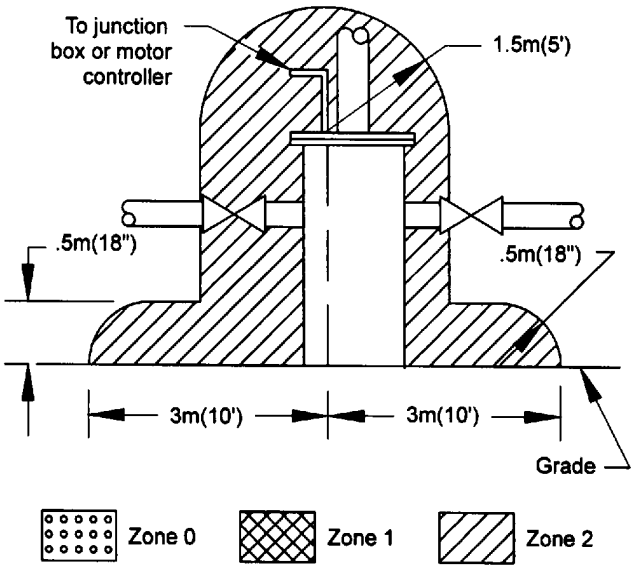


Figure 45—Electric Submersible Pumping Well in a Nonenclosed Adequately Ventilated Area Without a Cellar (See Section 10.5.2.3.1)

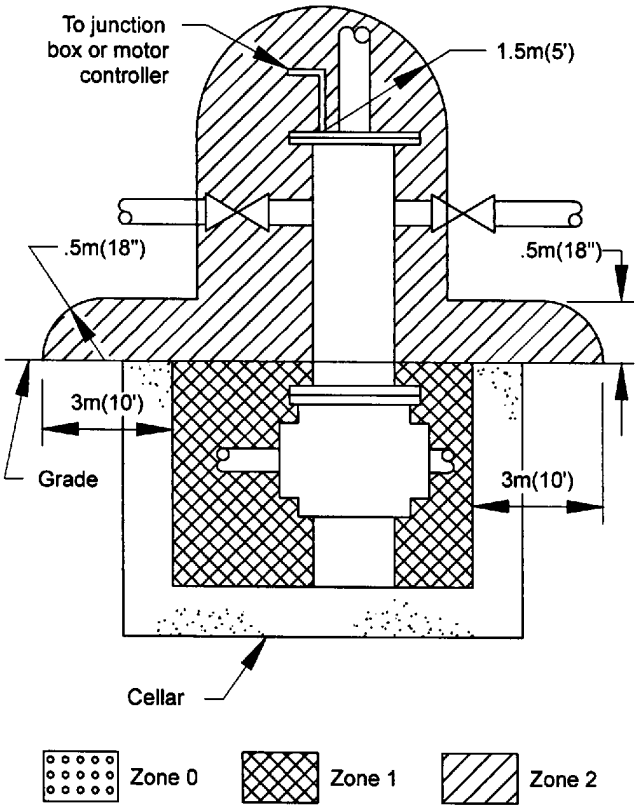


Figure 46—Electric Submersible Pumping Well in a Nonenclosed Adequately Ventilated Area With an Inadequately Ventilated Cellar (See Section 10.5.2.3.2)

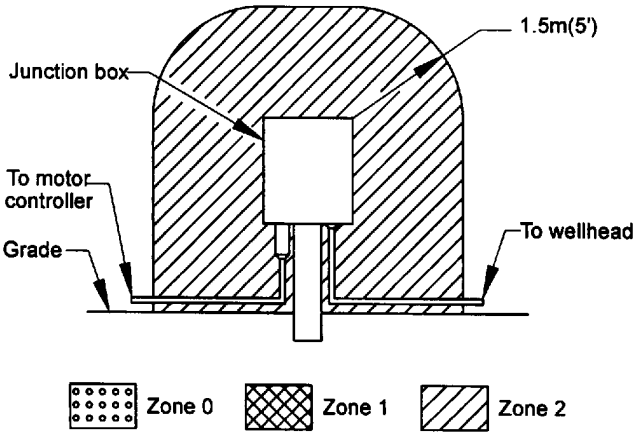


Figure 47—Junction Box in a Nonenclosed Adequately Ventilated Area Connected to an Electric Submersible Pump (See Section 10.5.2.3.3)

10.5.2.3.3.2 The interior of the junction box is classified Zone 1 if not vented.

10.5.2.3.4 The interior of a motor controller enclosure connected to an electric submersible pump through a vented junction box and sealing fitting by a cable or conduit is unclassified.

10.5.2.3.5 The interior of an adequately ventilated motor controller enclosure connected to an electric submersible pump through a vented junction box without an intervening sealing fitting by a cable or conduit is classified Zone 2.

10.5.2.3.6 The interior of an inadequately ventilated motor controller enclosure connected to an electric submersible pump through a vented junction box without an intervening sealing fitting by a cable or conduit is classified Zone 1.

10.5.2.3.7 The interior of a motor controller enclosure connected through a non-vented junction box or connected directly to an electric submersible pump by a cable or conduit in a nonenclosed adequately ventilated location is classified Zone 1.

10.5.2.3.8 Enclosed adequately ventilated areas containing electric submersible pumping wells or associated junction boxes are classified Zone 2 to the extent of the enclosed area.

10.5.2.3.9 Enclosed inadequately ventilated areas containing electric submersible pumping wells or associated junction boxes are classified Zone 1 to the extent of the enclosed area.

10.5.2.4 Hydraulic Subsurface Pumping Well. The location around a well produced with a hydraulic subsurface pump is classified the same as the location around a flowing well. Reference Section 10.5.1.

10.5.2.5 Gas Lift Well. The area around a gas lift well is classified the same as the area around a flowing well. Reference Section 10.5.1.

10.5.2.6 Plunger Lift Well. The area around a plunger lift well is classified the same as the area around a flowing well. Reference Section 10.5.1.

10.5.3 Injection Wells

10.5.3.1 The area around a flammable gas or liquid injection well is classified the same as the area around a flowing well. Reference Section 10.5.1.

10.5.3.2 The area around a nonflammable gas or liquid injection well is unclassified.

10.5.4 Multi-Well Installations

10.5.4.1 For a multi-well installation in a nonenclosed adequately ventilated area with less than 7.5 meters (25 feet) between wells (centerline to centerline), the area within a three meter (10 foot) radius of the centerline of each well is classified Zone 2.

10.5.4.2 Multiple completions within a single casing are considered a single-well installation.

10.6 OIL AND GAS PROCESSING AND STORAGE EQUIPMENT

10.6.1 Flammable Liquid Storage Tank

See Section 8.2.1.1, Fixed Roof Flammable Liquid Storage Tank, or Section 8.2.1.2, Open Top Floating Roof Flammable Liquid Storage Tank, as applicable.

10.6.2 Combustible Liquid Storage Tank

See Section 8.2.1.3, Combustible Liquid Storage Tank.

10.6.3 Hydrocarbon Pressure Vessel

Note: Classification is not because of the vessel itself, but for the control valves, sample valves, instrument drain valves, and numerous other valves and fittings around the vessel. Associated equipment (e.g., relief valves, rupture discs, and level controllers) must be considered separately.

Note: Some pressure vessels (e.g., filter-separators) are opened under normal conditions. In such cases, the area around the opening should be classified in accordance with Section 10.6.6, Launcher or Receiver.

10.6.3.1 The area around a hydrocarbon pressure vessel (e.g., oil-gas separator, treater, and glycol contactor) in a nonenclosed adequately ventilated area is classified as shown in Figure 48.

10.6.3.2 The area around a hydrocarbon pressure vessel in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area if all flammable gas vents, relief valve vents, and the like are extended to outside the enclosed area.

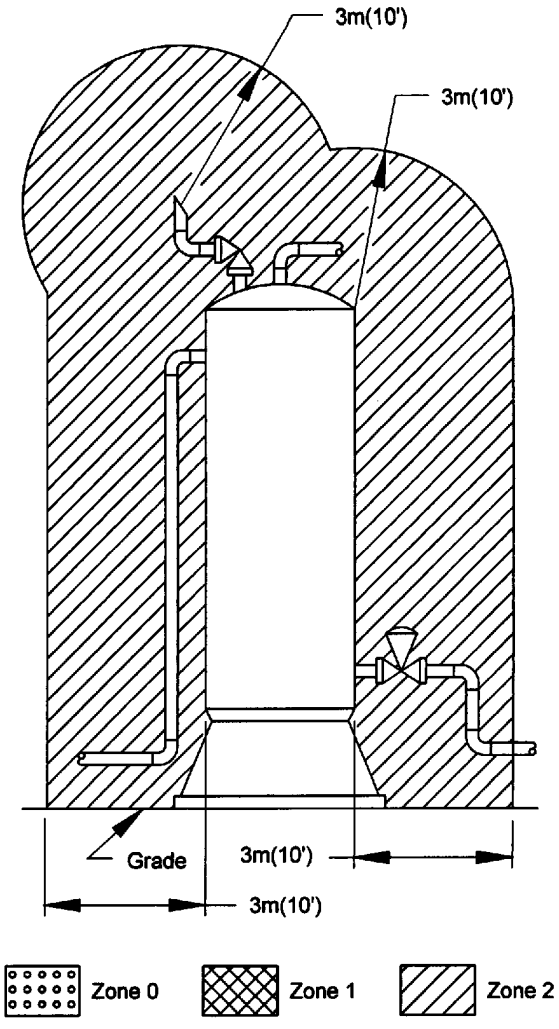


Figure 48—Hydrocarbon Pressure Vessel or Protected Fired Vessel in a Nonenclosed Adequately Ventilated Area
(See Sections 10.6.3.1, 10.6.5.1, and 10.6.7.1)

10.6.3.3 When a hydrocarbon pressure vessel is installed in an inadequately ventilated enclosed area, the area is classified Zone 1 to the extent of the enclosed area.

10.6.4 Header or Manifold

Note: As utilized in this section, a header or manifold is an assembly comprised of pipe flanges, valves, and miscellaneous fittings used to collect or distribute a common fluid or gas to or from a multiple of flowlines.

10.6.4.1 The area around a nonenclosed header or manifold located in an adequately ventilated area is unclassified.

10.6.4.2 The area around a header or manifold located in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.6.4.3 The area around a header or manifold located in an inadequately ventilated enclosure is classified Zone 1 to the extent of the enclosure.

Note: Associated equipment (such as control valves) must be considered separately.

10.6.5 Protected Fired Vessels

A protected fired vessel and the surrounding area is classified the same as for a hydrocarbon pressure vessel (Section 10.6.3).

10.6.6 Launcher or Receiver

Note: Blowdown and drain valve vents should he classified the same as shown by Figure 14 for process equipment vents.

10.6.6.1 Ball or Pig Launcher or Receiver

10.6.6.1.1 The area around an installation for launching or receiving balls or pigs into or from a producing or gathering line in a nonenclosed adequately ventilated area is classified as shown in Figure 49.

10.6.6.1.2 The area around such an installation in an adequately ventilated enclosed area is classified as shown in Figure 49, but Zone 2 for the remainder of the extent of the enclosed area.

10.6.6.1.3 The area around such an installation in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

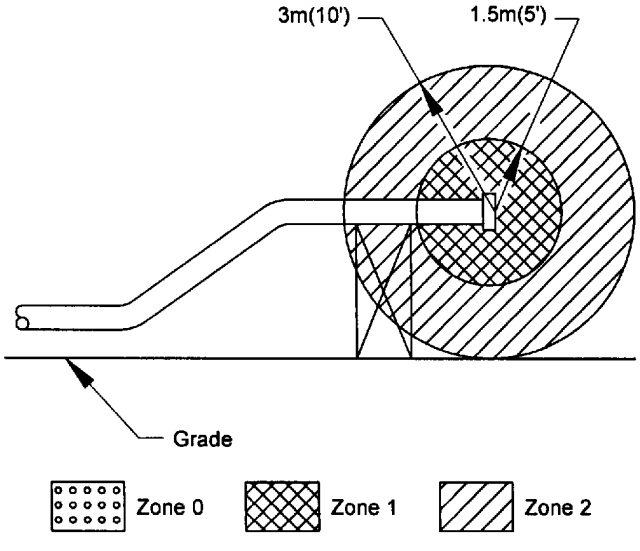


Figure 49—Ball or Pig Launching or Receiving Installation in a Nonenclosed Adequately Ventilated Area
(See Sections 10.6.6.1.1 and 10.6.6.2.1)

10.6.6.2 Through Flow Line (TFL) Tool Launcher or Receiver.

10.6.6.2.1 The area around a through flow (TFL) tool launcher or receiver in a nonenclosed adequately ventilated area is classified the same as illustrated in Figure 49 for a ball or pig launcher or receiver.

10.6.6.2.2 The area around such an installation in an adequately ventilated enclosed area is classified as shown in Figure 49, but Zone 2 for the remainder of the extent of the enclosed area.

10.6.6.2.3 The area around such an installation in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.6.7 DEHYDRATOR, STABILIZER, AND HYDROCARBON RECOVERY UNIT

10.6.7.1 Areas around such equipment in nonenclosed adequately ventilated areas are classified the same as shown in Figure 48 for hydrocarbon pressure vessels, except when an unprotected fire box or source of ignition is an integral part of such equipment. In this latter case, reference Section 10.6.5.1.2.

10.6.7.2 Areas around such equipment in an adequately ventilated enclosed area are classified Zone 2 to the extent of the enclosed area.

10.6.7.3 Areas around such equipment in an inadequately ventilated enclosed area are classified Zone 1 to the extent of the enclosed area.

10.6.8 Vents and Relief Valves

See Section 8.2.3, Vents and Relief Valves.

10.6.9 Hydrocarbon-Fueled Prime Movers

See Section 8.2.5, Hydrocarbon-Fueled Prime Movers.

10.6.10 Batteries

See Section 8.2.6, Batteries.

10.7 AUTOMATIC CUSTODY TRANSFER (ACT) UNITS

For details concerning areas around automatic custody transfer (ACT) units, refer to appropriate sections of this recommended practice (e.g., pumps, tanks, etc.). Areas around positive displacement meters should be classified the same as areas around control valves (Section 10.15.2). Areas around turbine meters should be classified the same as areas around block and check valves (Section 10.15.1). Areas around sample containers should be classified Zone 2 within 1.5 meters

(5 feet) of the container; sample valves are included in Section 10.15.3.

10.8 FLAMMABLE GAS-BLANKETED EQUIPMENT AND PRODUCED/PROCESSED WATER HANDLING EQUIPMENT

10.8.1 Produced/processed Water is any water, regardless of its source, that in the course of use may contain or mix with flammable liquids, gases or vapors.

10.8.1.1 Produced/processed water can be divided into at least three categories:

10.8.1.1.1 Produced/processed water that can be considered non-flammable. This water is usually the product of multiple stages of separation or filtration where a process upset would not result in the release of flammable concentrations. The area surrounding such water need not be classified solely by reason of the produced/processed water.

10.8.1.1.2 Produced/processed water that is likely to contain flammables due to process upset conditions. This water would usually be the product of one or more stages of separation or filtration where occasional process upsets might result in the release of small quantities of flammables for a short duration. Equipment for handling such water and flammable gas-blanketed equipment should be classified as described below.

10.8.1.1.2.1 Areas around flammable gas-blanketed equipment and produced/processed water-handling equipment installed in nonenclosed adequately ventilated areas are unclassified as shown in Figure 50.

Note: Refer to Section 8.2.3.1 for Process Equipment Vents.

10.8.1.1.2.2 The area around such equipment installed in an adequately ventilated enclosed area is classified as shown by Figure 50, but also Zone 2 for the remainder of the extent of the enclosed area if the equipment is vented to the outside of the enclosed area. If all equipment vents are not extended to the outside of the enclosed area, the entire enclosed area is classified Zone 1.

10.8.1.1.2.3 The area around such equipment installed in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.8.1.1.3 Produced/processed water that is likely to contain flammables on routine occasions or that could release sizable quantities of flammables for extended periods. Equipment handling this type of water should be classified as process equipment handling flammables. See Section 10.6 for guidance. Such equipment might consist of installations where process upset conditions could result in significant quantities of flammables in the water stream and where such conditions could exist unnoticed for extended periods of time.

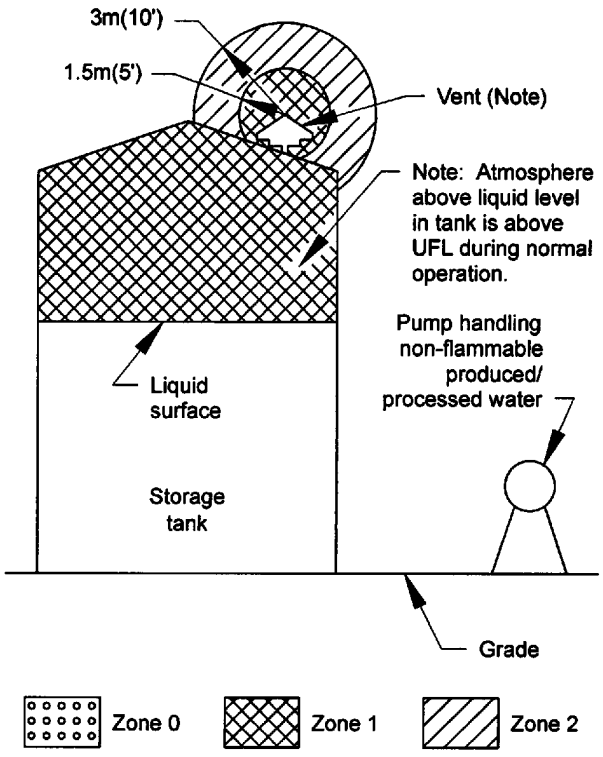


Figure 50—Flammable Gas-Blanketed and Produced Water-Handling Equipment in a Nonenclosed Adequately Ventilated Area (See Sections 10.8 and 10.12.4)

Such equipment could also consist of separation equipment prone to frequent upsets where the water stream contains flammable concentrations.

10.9 COMPRESSOR OR PUMP HANDLING FLAMMABLE LIQUIDS, GASES, OR VAPORS

10.9.1 The area around a compressor or pump handling flammable liquids, gases, or vapors in a nonenclosed adequately ventilated area is classified as shown in Figure 51 or Figure 52.

10.9.2 The area around a compressor or pump handling flammable liquids, gases, or vapors in an adequately ventilated enclosed area is classified as shown in Figure 53.

10.9.3 The area around a compressor or pump handling flammable liquids, gases, or vapors in an inadequately ventilated enclosed area is classified as shown in Figure 54.

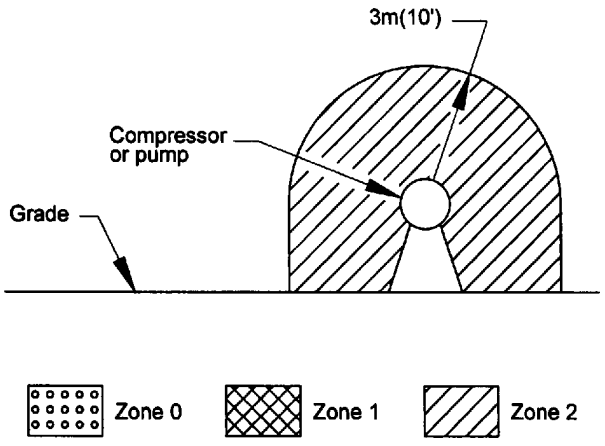


Figure 51—Compressor or Pump in an Adequately Ventilated Nonenclosed Area (See Section 10.9.1)

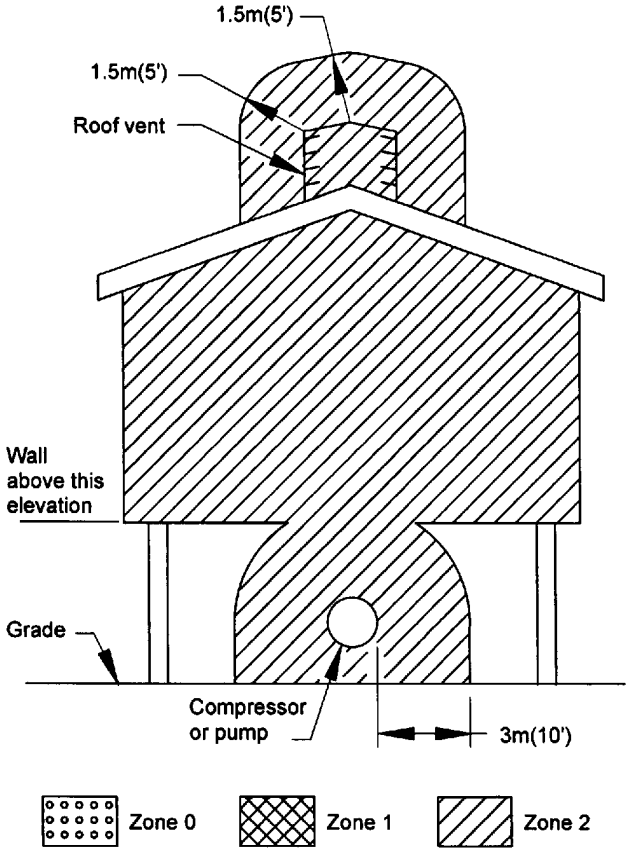


Figure 52—Compressor or Pump in an Adequately Ventilated Nonenclosed Area (See Section 10.9.1)

10.10 DRIP PANS

Included in this section are devices, which under abnormal operating conditions, collect and temporarily contain combustible or flammable liquids, at atmospheric pressure.

10.10.1 Drip pans that collect and temporarily contain combustible liquids are unclassified if the liquid is handled and contained below its flash point.

10.10.2 Drip pans that collect flammable liquids are classified as follows:

10.10.2.1 Drip pans that are continually drained to a containment system should be classified the same as drains as described in Section 10.13.

10.10.2.2 Drip pans that are not continually drained to a containment section should be classified the same as sumps as described in Section 10.12.

10.10.2.2.1 In nonenclosed, adequately ventilated locations, drip pans that (1) contain flammable liquids only in case of mechanical equipment failure, (2) are monitored routinely, (3) are capable of containing 38 liters (10 gallons) or less, and (4) have a maximum surface area of 0.6 square meters (6 square feet), should be classified Zone 1 inside the drip pan and Zone 2 for 0.5 meters (18 inches) above and within 0.5 meters (18 inches) of the perimeter of the drip pan.

10.11 INSTRUMENTS

This section addresses non-enclosed areas and enclosed areas (enclosures) sufficient in size to allow the entry of personnel. See Section 10.16, Control Panels, for enclosed areas (enclosures) insufficient in size to allow the entry of personnel.

10.11.1 Instruments Not Operated by Flammable Gas

Note: Included in this section are those instruments or other devices connected in hydrocarbon service (for example, devices used for flow, pressure, or level, analysis, measurement or control) that do not utilize flammable gas for motive force. Valves (as opposed to valve operators) should be classified in accordance with Sections 10.15.1 through 10.15.3.

10.11.1.1 The area surrounding such instruments (e.g., pressure switches and pressure transmitters) in a nonenclosed adequately ventilated area is unclassified.

10.11.1.2 The area surrounding such instruments in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area.

10.11.1.3 The area surrounding such instruments in an inadequately ventilated enclosure is classified Zone 1 to the extent of the enclosure.

Note: When evaluating small sources in large enclosed areas, sound engineering judgment must be used. For example, locating a metering pump in a large warehouse would typically not require classification of the entire warehouse, but only an area surrounding the metering pump. Ventilation rate, pro-

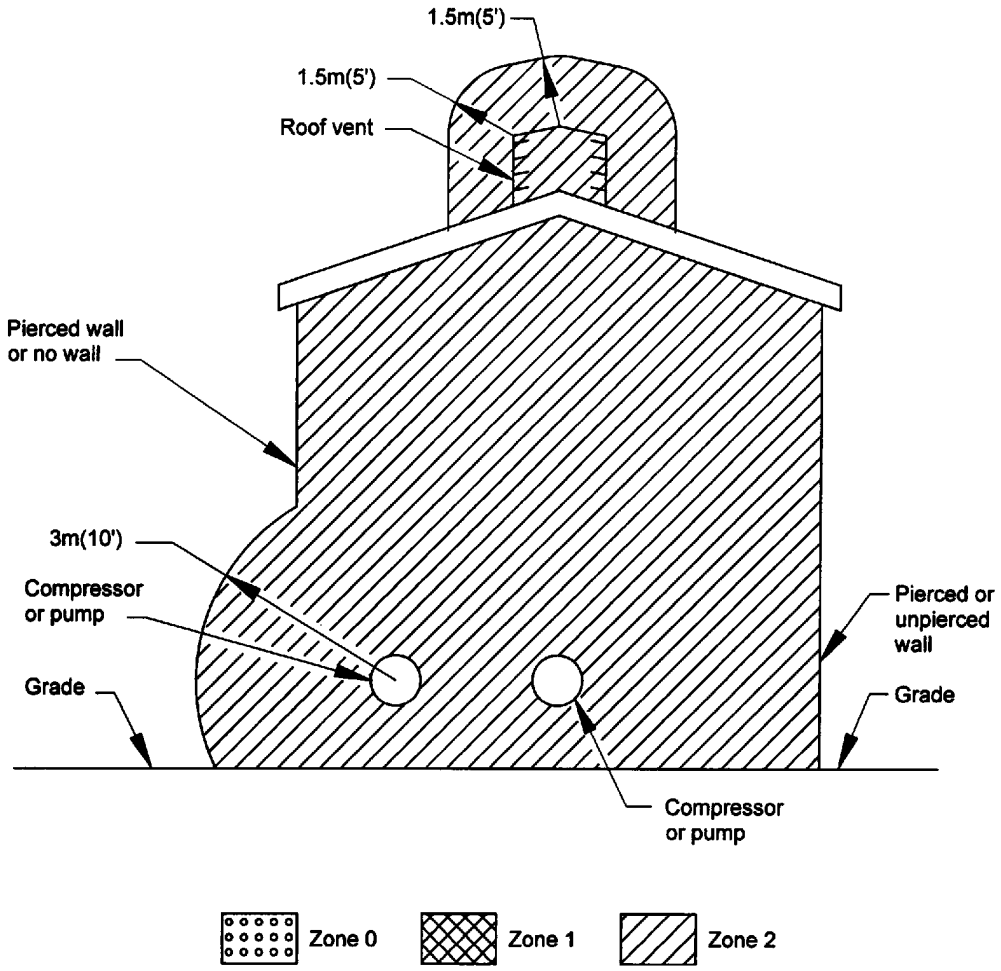
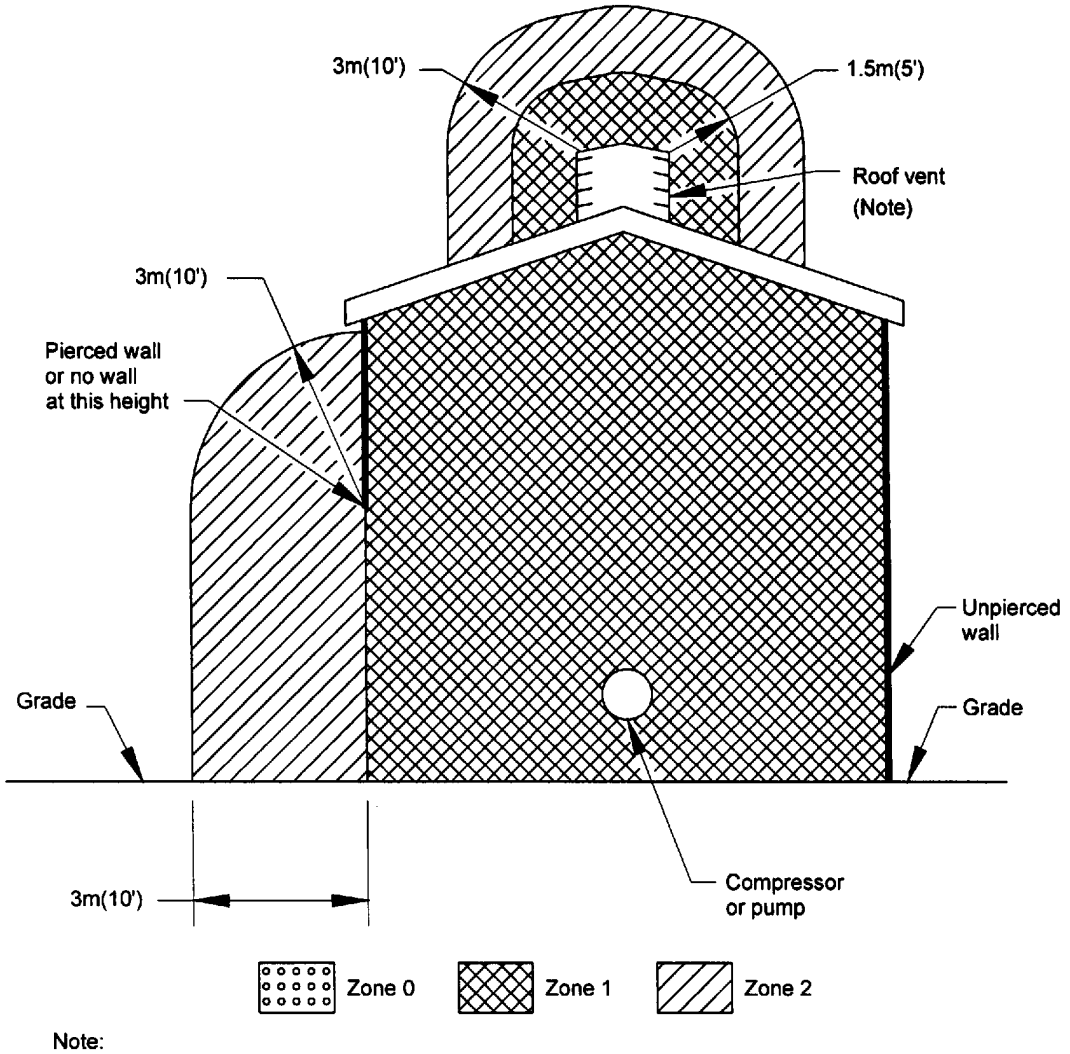


Figure 53—Compressor or Pump in an Adequately Ventilated Enclosed Area
(See Section 10.9.2)



Note:

The interior of the roof vent is classified Zone 1. Cross hatching has been omitted for drawing clarity.

Figure 54—Compressor or Pump in an Inadequately Ventilated Enclosed Area
(See Section 10.9.3)

cess pressure, process volume and the size of the enclosed area are all aspects of classification to be considered in these cases.

10.11.2 Instruments Operated by Flammable Gas

Note: Included in this section are those instruments or other devices connected in hydrocarbon service (for example, for flow, pressure, or level analysis, measurement, or control) that utilize flammable gas for motive force. Valves (as opposed to valve operators) should be classified in accordance with Sections 10.15.1 through 10.15.3.

10.11.2.1 When pneumatic instruments operated by flammable gas are located in a nonenclosed adequately ventilated area, the area is classified Zone 2 within 0.5 meters (18 inches) of the surface of the instruments. Additionally, any vent(s) must be classified in accordance with Figure 15.

10.11.2.2 When pneumatic instruments operated by flammable gas are located in an adequately ventilated enclosed area, the enclosed area is classified as shown by Figure 55 provided all devices are vented to outside the enclosed area. If all devices are not vented to outside the enclosed area, the enclosed area is classified Zone 1 to the extent of the enclosed area.

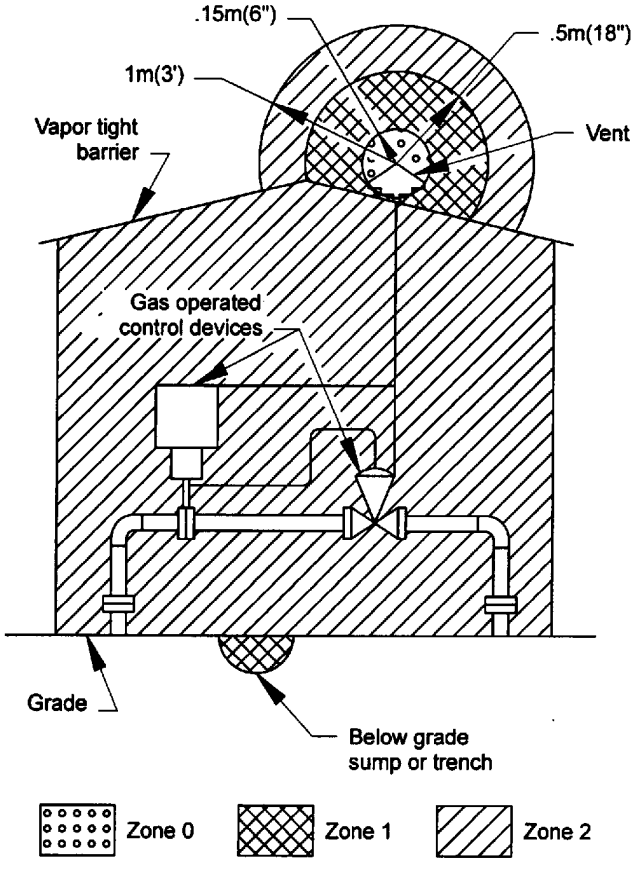


Figure 55—Flammable Gas-Operated Instruments in an Adequately Ventilated Enclosed Area With All Devices Vented to the Outside
(See Section 10.11.2.2)
Note: For Vents, See Section 8.2.3.2

10.11.2.3 When pneumatic instruments operated by flammable gas are located in an inadequately ventilated enclosed area, the enclosed area is classified as shown by Figure 56.

10.12 SUMPS

Note: Included in this section is equipment intended to collect and contain flammable liquids at atmospheric pressure.

10.12.1 The area surrounding an open sump that can contain flammable liquid and is located in a nonenclosed adequately ventilated area is classified as shown by Figure 57.

Note: Dimension "D" in Figure 57 is the diameter [in meters (feet)] of round sumps and the effective diameter of square or other shaped sumps. The effective diameter is defined as the surface area of the sump [in square meters (square feet)] divided by π (3.1416), subject to a maximum of three meters (10 feet). The distance "D" is measured from the perimeter of the sump.

10.12.2 The location surrounding an open sump that can contain flammable liquid and is located in an adequately ventilated enclosed area is classified as shown by Figure 57, but Zone 2 for the remainder of the extent of the enclosed area.

10.12.3 The area surrounding an open sump that can contain flammable liquid and is located in an inadequately ventilated area is classified as illustrated for mud tanks in Figure 34.

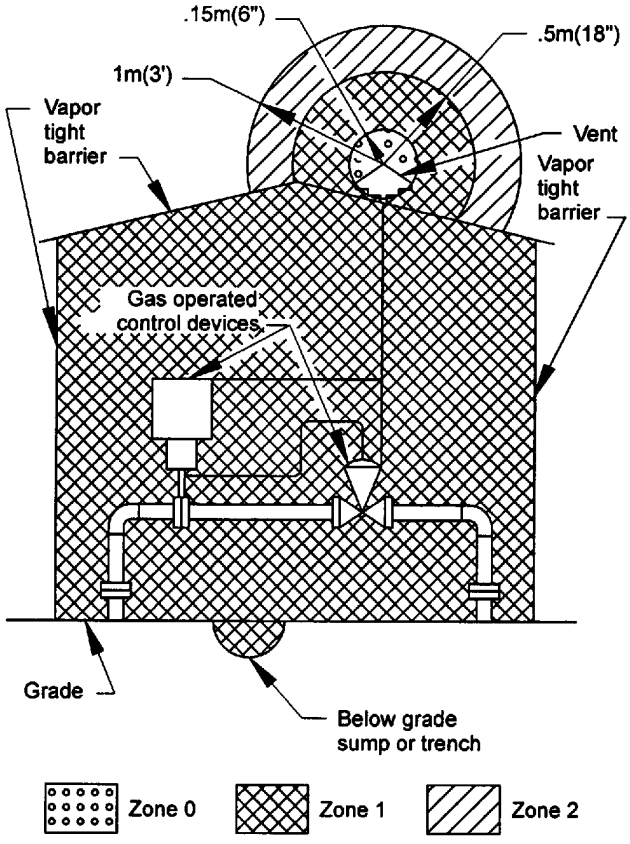


Figure 56—Flammable Gas Operated Instruments In an Inadequately Ventilated Enclosed Area
(See Section 10.11.2.3)

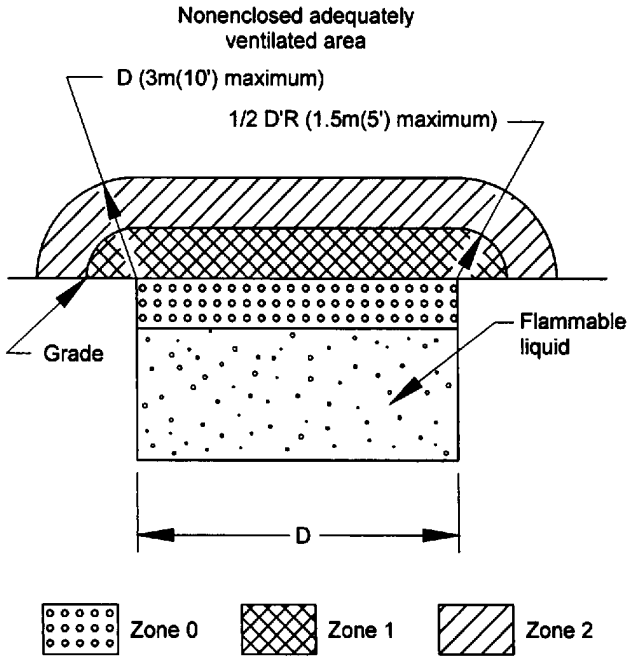


Figure 57—Open Sump in Nonenclosed Adequately Ventilated Area
(See Sections 10.12.1, 10.12.2, and 10.13 Note 4)

10.12.4 Closed sumps that can contain flammable liquid should be classified the same as shown by Figure 50 for flammable gas-blanketed and produced water-handling equipment.

10.13 DRAINS

Note 1: Included in this section are devices intended to collect and remove, but not continuously contain flammable liquids. Included also are devices intended to collect and remove, but not continuously contain, combustible liquids if their temperatures are above their flashpoints.

Note 2: An open drain is defined as a drain that is open to the atmosphere [at its entrance (drain opening) or elsewhere] before (or where) its discharge enters a sump, pit, or other containment device.

Note 3: A closed drain is defined as a drain that is piped to a sump or other closed containment device without being open to the atmosphere, whether the containment device is at atmospheric or elevated pressure.

Note 4: An open containment system is defined as a system open to the atmosphere. Reference Figure 57.

Note 5: A drain opening is defined as an opening in the drain system where the drained fluid actually enters the drain piping from the atmosphere.

Note 6: A drain entry is defined as an open fluid collection system, such as a trough or gutter, that routes the drained fluid to the drain opening,.

Note 7: A liquid trap is defined as a device that is designed and maintained to prevent gases and vapors from a containment system from being vented through a drain opening in the opposite direction for which it is designed.

10.13.1 Type 1 Open Drains. Type 1 Open Drains are open drains designed to be operated in such a manner to prevent flammables from entering or exiting the drain system.

10.13.1.1 Nonenclosed areas and enclosed areas without heavier-than-air flammable sources (a) with Type 1 open drains including only open fluid collection systems (i.e., drain entries) designed to collect only non-flammable fluids and (b) without drains connected to drain or containment systems designed to collect or contain flammable fluids are classified in accordance with Figure 58.

10.13.1.2 Nonenclosed areas and enclosed, adequately ventilated areas without heavier-than-air flammable sources (a) with Type 1 open drains including only open fluid collection systems (i.e., drain entries) designed to collect only non-flammable fluids and (c) connected to, but properly isolated from (e.g., with liquid traps), drain systems designed to collect or contain flammable fluids that gravity drain those fluids to open containment areas (e.g., pits) are classified in accordance with Figure 58.

10.13.2 Type 2 Open Drains. Type 2 Open Drains are open drains that do not allow an accumulation of flammables above grade; flammables may accumulate below grade, however, due to flammable liquids or heavier-than-air flammable vapors settling into low spot(s) created by the drain or drain piping.

10.13.2.1 Nonenclosed areas and enclosed areas with heavier-than-air flammable sources (a) with Type 2 open drains including only open fluid collection systems (i.e., drain entries) designed to collect only non-flammable fluids and (b) without drains connected to drain or containment systems designed to collect or contain flammable fluids are classified in accordance with Figure 59.

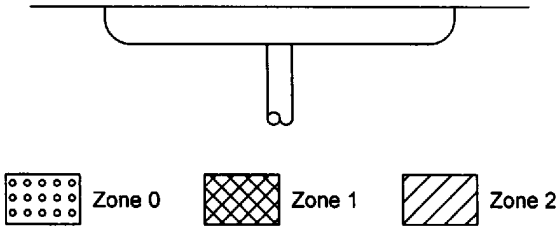


Figure 58—Type 1 Open Drain System
(See Section 10.13.1.1)

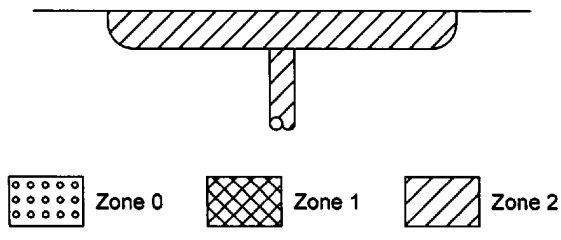


Figure 59—Type 2 Open Drain System
(See Section 10.13.2.1)

10.13.3 Type 3 Open Drains. Type 3 Open Drains are open drains that can allow releases (through drain openings) of lighter-than-air flammable gases or vapors at atmospheric pressure.

10.13.3.1 Adequately ventilated, nonenclosed areas (a) with Type 3 open drains including only open fluid collection systems designed for non-flammable fluids and (b) with drains connected to drain systems designed to contain flammable fluids only for brief periods of time while gravity drains these fluids to open containment areas are classified in accordance with Figure 60.

10.13.3.2 Adequately ventilated, nonenclosed areas with (a) Type 3 open drains including only open fluid collection systems designed to contain flammable fluids only for brief periods of time while gravity drains these fluids to open containment areas are classified in accordance with Figure 60.

10.13.3.3 Adequately ventilated, nonenclosed areas (a) with Type 3 open drains including only open fluid collection systems designed for flammable fluids and (b) with drains connected to, but properly isolated from (e.g., with liquid traps), closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 60.

10.13.3.4 Adequately ventilated, enclosed areas (a) containing Type 3 open drains including only open fluid collection systems designed for non-flammable fluids and (b) with drains connected to drain systems designed to contain flammable fluids only for brief periods of time while gravity drains these fluids to open containment areas are classified Zone 2 to the extent of the enclosed area in accordance with Figure 61.

10.13.3.5 Adequately ventilated, enclosed areas with (a) Type 3 open drains including only open fluid collection systems designed to contain flammable fluids only for brief periods of time while gravity drains these fluids to open containment areas are classified in accordance with Figure 61.

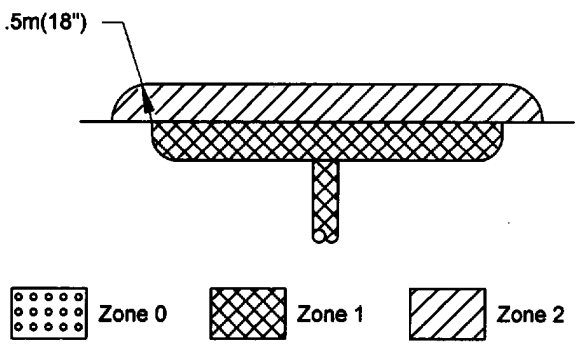


Figure 60—Type 3 Open Drain System in Nonenclosed Area
See Section 10.13.3.1

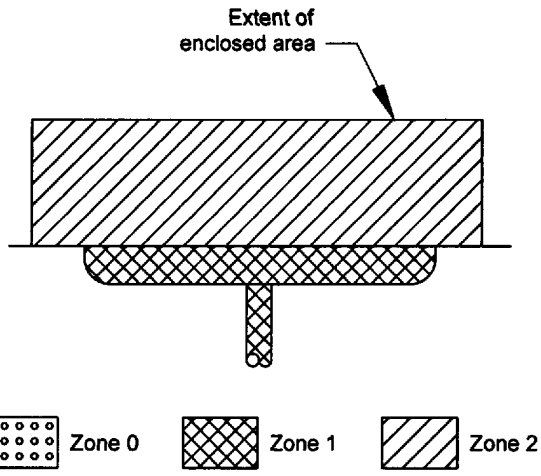


Figure 61—Type 3 Drain System in Enclosed Area
(See Sections 10.13.3.4, 10.13.3.5, and 10.13.3.6)

10.13.3.6 Adequately ventilated, enclosed areas (a) with Type 3 open drains including only open fluid collection systems designed for flammable fluids and (b) with drains connected to, but properly isolated from (e.g., with liquid traps), closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 61.

10.13.4 Type 4 Open Drains. Type 4 Open Drains are open drains that can allow releases (through drain openings) of lighter-than-air flammable gases or vapors at greater than atmospheric pressure.

10.13.4.1 Adequately ventilated nonenclosed areas (a) with Type 4 open drains including only open fluid collection systems designed for non-flammable fluids and (b) connected to, but not properly isolated from (e.g., with drain traps), closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 62.

10.13.4.2 Adequately ventilated, nonenclosed areas (a) with Type 4 open drains including only open fluid collection systems designed for non-flammable fluids, and (b) connected to, but not properly isolated from (e.g., with liquid traps), closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 62.

10.13.4.3 Adequately ventilated, nonenclosed areas (a) with Type 4 open drains including only open fluid collection systems designed for flammable fluids, and (b) connected to, but not properly isolated from (e.g., with liquid traps), closed containment system(s) are classified in accordance with Figure 62.

10.13.4.4 Adequately ventilated, nonenclosed areas with (a) Type 4 open drains including only open fluid collection

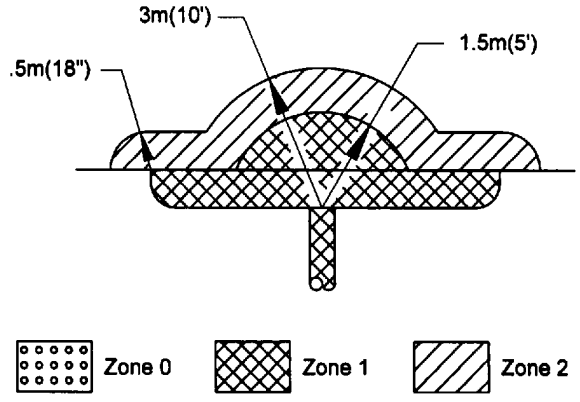


Figure 62—Type 4 Open Drain System in Nonenclosed Area
(See Sections 10.13.4.1, 10.13.4.2, 10.13.4.3, and 10.13.4.4)

systems designed for flammable fluids, and (b) connected to, but not properly isolated from (e.g., with liquid traps), closed containment system(s) are classified in accordance with Figure 62.

10.13.4.5 Enclosed areas (a) with Type 4 open drains including only open fluid collection systems designed for flammable or non-flammable fluids and (b) connected to, but not properly isolated from (e.g., with drain traps), closed containment system(s) designed to contain flammable fluids are classified Zone 1 to the extent of the enclosed area in accordance with Figure 63.

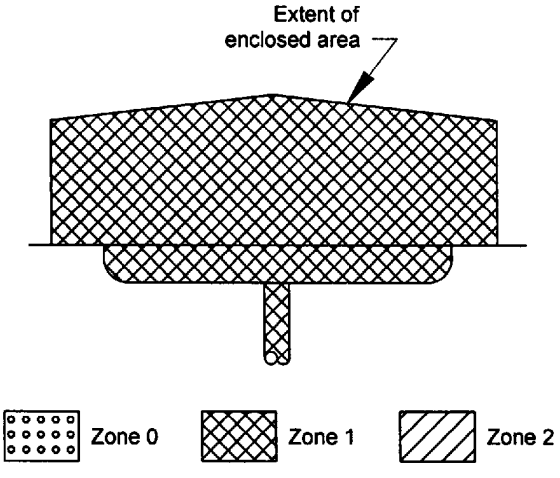


Figure 63—Type 4 Open Drain System in Enclosed Area
(See Sections 10.13.4.5 and 10.13.4.6)

10.13.4.6 Enclosed areas (a) with open drains including only open fluid collection systems designed for non-flammable fluids, and (b) connected to, but not properly isolated from (e.g., with liquid traps), closed containment system(s) designed to contain flammable fluids are classified in accordance with Figure 63.

10.13.5 Closed drains. Closed drain systems should be considered the same as comparable process piping. Piping that contains valves that could open such drains to the atmosphere should be considered the same as process equipment vents; see Section 8.2.3.1.

10.14 RESERVED FOR FUTURE USE

10.15 SCREWED CONNECTIONS, FLANGES, VALVES, AND VALVE OPERATORS

Note: Included in this section are valves with all ports connected to closed piping (or tubing) systems. Vented ports must be classified at their point of release in accordance with Section 8.2.3.

10.15.1 Screwed Connections, Flanges, Block Valves, and Check Valves.

10.15.1.1 The area around screwed connections, flanges, block valves, and check valves in nonenclosed adequately ventilated areas is unclassified.

10.15.1.2 The area around screwed connections, flanges, block valves, and check valves in adequately ventilated enclosed areas is Zone 2 to the extent of the enclosed area.

10.15.1.3 The area around screwed connections, flanges, block valves, and check valves in an inadequately ventilated enclosed area is Zone 1 to the extent of the enclosed area.

10.15.2 Process Control Valves [including, but not limited to, regulators, back pressure valves, and level control valves (but not level control switches)].

10.15.2.1 The area around process control valves in nonenclosed adequately ventilated areas is classified Zone 2 within 0.5 meters (18 inches) of the stem seal or similar seal.

10.15.2.2 The area around process control valves in adequately ventilated enclosed areas is Zone 2 to the extent of the enclosed area.

10.15.2.3 The area around process control valves in inadequately ventilated enclosed areas is Zone 1 to the extent of the enclosed area.

10.15.3 Sample Valves, Instrument Drain Valves, Gauge Valves, and Similar Devices.

10.15.3.1 The area surrounding sample and instrument drain valves, gauge valves, and similar devices is classified the same as screwed connections, flanges, block valves, and check valves in accordance with Section 10.15.1.

10.15.3.2 The area surrounding the final discharge points of sample and instrument drain valves, gauge valves, and similar devices is classified Zone 2 for 0.5 meters (18 inches) as shown by Figure 39 and Figure 40.

10.15.4 Valve Operators

10.15.4.1 The area around valve operators utilizing air or other nonflammable gas or fluid as the power medium is unclassified.

10.15.4.2 The area around valve operators utilizing flammable gas or fluid as the power medium in a nonenclosed adequately ventilated area is classified Zone 2 within 0.5 meters (18 inches) of the operator provided all vents are extended to the outside of the area. If all vents are not extended to the outside of the area, reference Section 8.2.3.2.

10.15.4.3 The area around valve operators utilizing flammable gas or fluid as the power medium in an adequately ventilated enclosed area is classified Zone 2 to the extent of the enclosed area provided all vents are extended to the outside of the area. If all vents are not extended to the outside of the area, reference Section 8.2.3.2.

10.15.4.4 The area around control valve operators utilizing flammable gas or flammable hydraulic fluid in an inadequately ventilated enclosed area is classified Zone 1 to the extent of the enclosed area.

10.16 CONTROL PANELS CONTAINING INSTRUMENTATION UTILIZING OR MEASURING FLAMMABLE LIQUIDS, GASES, OR VAPORS

This section addresses enclosed areas (enclosures) insufficient in size to allow the entry of personnel. See Section 10.11, Instruments, for non-enclosed areas and enclosed areas (enclosures) sufficient in size to allow the entry of personnel.

Note: Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment, such as vents.

10.16.1 For the purpose of this section, control panels refer to enclosures (panels) that contain, or have attached to them, instruments with process connections to flammable or combustible fluids for the analysis, measurement, indication, or control of process variables such as flow, pressure, level, and temperature, and also contain the interfaces for the associated electrical wiring.

10.16.2 The interior of a control panel should not be classified less hazardous than the classification of the surrounding area unless additional safety measures, such as combustible gas detectors (See Section 6.5) or purged enclosures (See Section 3.2.19) are provided.

10.16.3 The interior of control panels where flammable gas is vented (continuously or intermittently) to the inside of the enclosure is classified Zone 1 to the extent of the enclosure. See Figure 64.

Note: Typical instruments that may vent flammable gas include current-to-pressure (I/P) transducers, sampling analyzers, pneumatic controllers, and pressure regulators.

10.16.4 The interior of control panels where all flammable gas is vented to the outside of the enclosure is classified as follows:

10.16.4.1 The interior of inadequately ventilated control panels is classified Zone 1 to the extent of the enclosure. See Figure 65.

10.16.4.2 Where instruments are located inside an adequately ventilated enclosure, the interior of the enclosure is classified Zone 2 to the extent of the enclosure. See Figure 66.

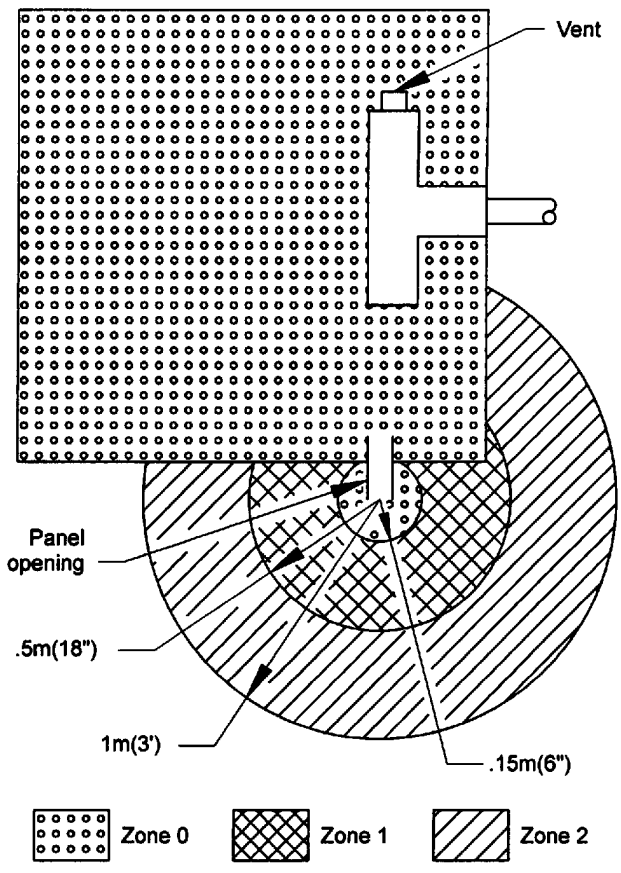


Figure 64—Control Panel With Flammable Gas Vented to the Inside of the Enclosure (See Section 10.16.3)

10.16.5 Where an instrument is located outside of, but attached to, an enclosure, and its electrical connection is separated from flammable process fluid by more than one barrier and leakage of the primary seal will be obvious, the interior of the enclosure containing the interconnecting wiring is unclassified.

10.16.6 Where an instrument is located outside of, but attached to, an enclosure, and its electrical connection is separated from flammable process fluid by a single barrier, the interior of the enclosure containing its interconnecting wiring is classified Zone 2 to the extent of the enclosure.

10.16.7 Panels located in enclosed areas sufficient in size to allow the entry of personnel (e.g., buildings) should be classified in accordance with Section 10.11.

10.16.8 For area classification of instrument vents, refer to Section 8.2.3.2.

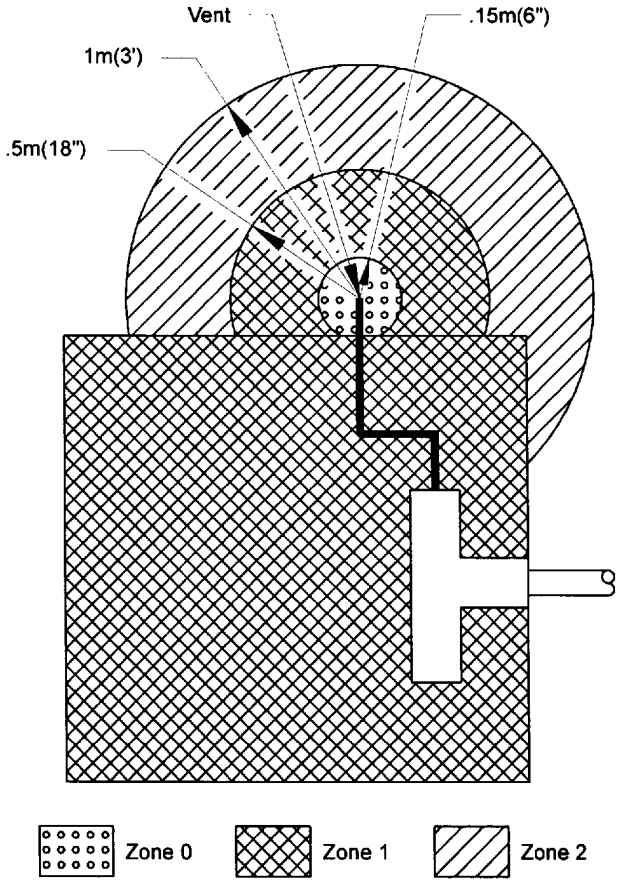


Figure 65—Inadequately Ventilated Control Panel With Instruments Inside
(See Section 10.16.4.1)

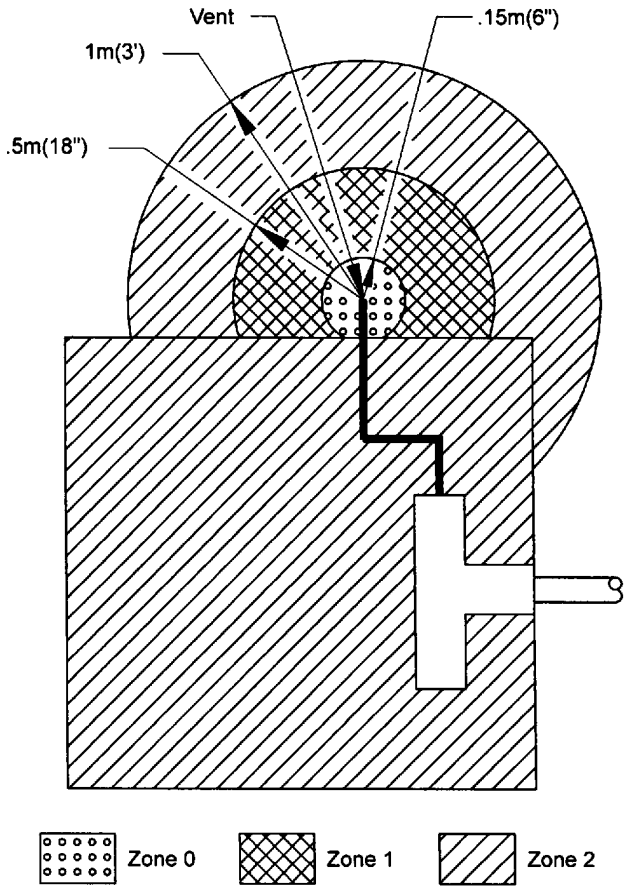


Figure 66—Adequately Ventilated Control Panel With Instruments Inside
(See Section 10.16.4.2)

11 Recommendations for Determining Degree and Extent of Classified Locations on Mobile Offshore Drilling Units (MODUs)

11.1 GENERAL

11.1.1 This section presents guidelines for classifying locations for electrical installations on Mobile Offshore Drilling Units (MODUs) where flammable liquids, gases or vapors may be present.

This section is not intended to address the classification of locations due to catastrophic failures that result in uncontrolled releases of flammable (explosive) liquids, gases, or vapors. Catastrophic failures (for example, well blowouts) are extreme conditions that require emergency measures at the time of occurrence.

11.1.2 This section applies to all types of MODUs without production facilities, including, but not limited to, the following types:

a. Semi-submersible Units (Floating Column-Stabilized Units)

b. Submersible Units (Bottom-Sitting Column-Stabilized Units)

c. Self-elevating Units (Bottom-Sitting Units with Moveable Legs)

d. Barge-type Units (Surface Units)

e. Drillships (Surface Units)

11.1.3 Recommendations for determining the degree and extent of classified locations for MODUs containing production facilities are addressed in Section 12.

11.2 DEFINITIONS SPECIFIC TO MODUS

The specific definitions below are unique to MODUs. Where definitions of the same or similar terms are given elsewhere within this recommended practice, the definitions given elsewhere are superseded by the definitions below.

11.2.1 Locations and Spaces

11.2.1.1 Locations, Open (Outdoor): Locations substantially free of structures (or other obstructions) where natural ventilation is not impeded and causes the rapid dispersion (dilution) of gases and vapors, and stagnant areas are not present.

11.2.1.2 Locations, Semi-enclosed: Locations where natural conditions of ventilation are notably different from those on open decks due to the presence of structures such as roofs, windbreaks and bulkheads and which are so arranged that dispersion of gas may occur. (IMO–MODU Code 1.3.34)

11.2.1.3 Spaces, Enclosed: Spaces delineated by floors, bulkheads and decks, which may have doors or windows. (IMO–MODU Code 1.3.33)

11.2.2 Tanks

11.2.2.1 Tanks, Accessible: Tanks that under normal operating conditions are sealed against gas and vapor leakage, but the interior of which may be readily accessed for inspection and maintenance from within the location.

11.2.2.2 Tanks, Closed Top: Tanks with limited number of small openings or penetrations, such as shafts, through which gas may occasionally leak within the location.

11.2.2.3 Tanks, Open: Tanks that allow the continuous free communication of the tank's internal atmosphere into the surrounding location or space.

11.2.2.4 Tanks, Sealed: Tanks that are sealed against gas and vapor leakage and are without provisions for inspection or maintenance from within the location.

11.2.3 Ventilation

Note: Throughout this section, the terms "Artificial", "Mechanical", and "Forced" Ventilation should be considered interchangeable.

11.2.3.1 Ventilation, Adequate: The degree of ventilation (i.e., the movement and transfer of air) achieved when, under normal operating conditions, the ventilation provided meets the location's required criteria (for example, equal to or greater than a specified minimum number of air changes per hour).

11.2.3.2 Ventilation, General Artificial: Movement of air and its replacement with fresh air by artificial means (e.g., fans) and applied to a general area. (IEC 79-10, Mod)

11.2.3.3 Ventilation, Inadequate: The degree of ventilation (i.e., the movement and transfer of air) achieved when, under normal operating conditions, the ventilation provided does not meet the location's required criteria (for example, less than a specified minimum number of air changes per hour).

11.2.3.4 Ventilation, Local Artificial: Movement of air and its replacement with fresh air by artificial means (usually extraction) applied to a particular source of release or local area. (IEC 79-10, Mod)

11.2.3.5 Ventilation, Natural: Movement of air and its replacement with fresh air due to the effects of wind or temperature gradients, or both. (IEC 79-10, Mod)

11.2.3.6 Ventilation, No: The lack of ventilation in locations where no arrangements have been made to cause air replacement with fresh air.

11.3 RESERVED FOR FUTURE USE

11.4 CLASSIFIED LOCATIONS ON MOBILE OFFSHORE DRILLING UNITS (MODUS)

The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered during operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment ñ employing information presented in this recommended practice and other publications. Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment. Also, specific examples listed consider only a MODU as a "stand-alone" unit and do not take into account the possible influence of hazardous (classified) locations on adjacent structures to the classification of locations on the MODU.

11.4.1 Drilling Areas

11.4.1.1 Drilling areas considered for classification by this section include the following:

a. Drill floor and derrick areas
b. Substructure or moonpool areas
c. Mud tanks
d. Mud ditches or troughs
e. Mud pumps
f. Mud processing equipment
g. Shale shakers
h. Desanders or desilters
i. Vents
j. Diverter line outlets
k. Blowout preventers (BOPs)

11.4.2 Well Test Equipment Areas

11.4.2.1 Well Test Equipment areas considered for classification include the following:

a. Separation equipment
b. Metering equipment
c. Liquid storage equipment
d. Burner booms
e. Gas lift equipment

11.4.3 Other Areas

11.4.3.1 Other areas considered for classification by this section include the following:

a. Paint lockers
b. Battery rooms
c. Helicopter fuel storage areas

11.4.4 Drains

11.4.4.1 Drains in MODU service do not constitute a source of release that must be considered for area classification purposes.

11.4.4.2 Drains for well test equipment must consider the requirements of Section 10 for area classification purposes.

11.5 BASIS FOR AREA CLASSIFICATION

Areas are classified on each installation to reflect normally anticipated operating conditions. Factors that are taken into account include the following:

a. possible sources of release,
b. whether or not areas are open, enclosed, or semi-enclosed,
c. ventilation, and
d. the nature of the release (mist, gas or vapor, etc.).

Area classifications recommended in this section are based on spaces being ventilated or pressurized in accordance with the Sections 11.5.1 through 11.5.3.

11.5.1 Ventilation and Pressurization

11.5.1.1 General

11.5.1.1.1 Ventilation is a means of diluting a possible release of flammable gas or vapor in an area.

11.5.1.1.2 Pressurization is a means to prevent flammable gas-air or vapor-air mixtures from outside a pressurized area from entering the area.

11.5.1.2 Attention should be given to the direction of airflow and the locations of ventilation inlets and outlets to minimize the possibility of cross contamination. Provisions need to be made for the introduction of air in a manner to properly distribute ventilation; that is, air should not be permitted to flow directly from the air inlet to the air outlet (short-circuited) without removing air previously within the enclosed area, or from the air outlet back into the air inlet.

11.5.1.3 Ventilation inlets should be located in unclassified (non-hazardous) locations.

11.5.1.4 Ventilation systems for hazardous (classified) locations should be completely separate from those for unclassified (non-hazardous) locations.

11.5.2 Ventilation and Pressurization of Hazardous (Classified) Locations

11.5.2.1 Enclosed hazardous (classified) locations are to be provided with ventilation as required to maintain them at a pressure lower than adjacent less hazardous locations by a minimum differential of 25 Pa (0.1 in. H_20).

11.5.2.2 The arrangement of ventilation inlet and outlet openings in the space is to be such that the entire space is efficiently ventilated—giving special consideration to locations of equipment that may release flammable vapor or gas and to spaces where flammable vapor or gas may accumulate.

11.5.2.3 Enclosed hazardous (classified) spaces containing any open portion of the mud system should be ventilated at a minimum rate of 12 air changes per hour.

11.5.2.4 The outlet air from Zone 0, Zone 1, and Zone 2 spaces should be led in separate ducts to outdoor locations that are the same classification or less hazardous than the ventilated space.

Note: Zone 1 areas are considered less hazardous that Zone 0 areas. Zone 2 areas are considered less hazardous than Zone 1 areas. Unclassified areas are considered less hazardous than Zone 2 areas.

11.5.2.4.1 Ventilation ducts should be at negative pressure [minimum differential of 25 Pa (0.1 in. H_20)] in relation to

less hazardous locations and at positive pressure [minimum differential of 25 Pa (0.1 in. H_2O)] in relation to more hazardous locations. Such ducts should be rigidly constructed to avoid air leaks.

11.5.2.4.2 The interior of ducts exhausting hazardous (classified) locations should be of the same classification as the area that they exhaust (ventilate).

11.5.3 Ventilation and Pressurization of Unclassified (Non-Hazardous) Locations

11.5.3.1 Ventilation inlets and outlets for unclassified (non-hazardous) locations should be located in unclassified (non-hazardous) locations.

11.5.3.2 Ventilation ducts passing through a hazardous (classified) location should be positive pressure [minimum differential of 25 Pa (0.1 in. H_2O)] in relation to the hazardous (classified) location.

11.6 CLASSIFICATION OF HAZARDOUS (CLASSIFIED) LOCATIONS

11.6.1 Class I, Zone 0 Hazardous (Classified) Locations

11.6.1.1 In some locations ignitible concentrations of flammable gases or vapors may be present continuously or for long periods of time. These locations are designated as Class I, Zone 0 hazardous (classified) locations. The following hazardous (classified) locations should be considered Class 1, Zone 0:

11.6.1.1.1 The internal spaces of tanks and piping systems vented to the atmosphere (i.e., operating at or near atmospheric pressure) intended to contain active drilling mud or produced crude oil or natural gas, and

11.6.1.1.2 Other locations in which flammable liquid, gas, or vapor is continuously present or is present for long periods of time.

Note: Class I, Zone 0, Zone 1, and Zone 2 hazardous (classified) locations are defined as "...locations where fire or explosive hazards may exist due to flammable gases or vapors." [NEC 505-1]. "Locations shall be classified depending on the properties of the flammable vapors, liquids, or gases—that may be present and the likelihood that a flammable or combustible concentration or quantity is present." [NEC 500-2]. For a mixture to be flammable, air/oxygen must be present (in the correct percentages); see Section 4. Air/oxygen normally is not present inside pressure vessels (e.g., oil-water-gas separators and chemical-electric treaters) and pressure piping. Thus, the interior of such vessels and piping normally is not classified. Individuals classifying locations should understand the operation of process equipment and the use of interconnecting piping before making a decision to classify or to not classify all (interior and exterior) locations containing such equipment or piping. See also 3.2.20, explosive gas atmosphere.

11.6.2 Class 1, Zone 1 Hazardous (Classified) Locations

11.6.2.1 The following locations should be considered as Class 1, Zone 1:

11.6.2.1.1 An enclosed space containing any part of the mud circulating system between the well and the final degassing discharge that has an opening into the enclosed space.

11.6.2.1.2 Enclosed spaces or semi-enclosed locations that are below the drill floor and contain a possible source of release (such as the top of a bell nipple).

11.6.2.1.3 Enclosed spaces that are on the drill floor and that are not separated by a solid floor from the spaces specified in 11.6.2.1.2.

11.6.2.1.4 In outdoor or semi-enclosed locations, the area within 1.5 m (5 ft) from the boundaries of (a) openings to equipment that is part of the mud system as specified in 11.6.2.1.1, (b) ventilation outlets from Class 1, Zone 1 spaces, and (c) accesses (e.g., doors, windows, or manways) to Class 1, Zone 1 spaces.

11.6.2.1.5 Pits, ducts or similar structures in locations that would otherwise be Class 1, Zone 2, but that are so arranged that dispersion of gas may not occur.

11.6.3 Class 1, Zone 2 Hazardous (Classified) Locations

11.6.3.1 Enclosed spaces that contain open sections of the mud circulating system between the final degassing discharge to the mud pump suction connection at the mud pit.

11.6.3.2 Outdoor locations within the boundaries of the drilling derrick up to a height of 3 m (10 ft) above the drill floor.

11.6.3.3 Semi-enclosed locations below and contiguous to the drill floor and to the boundaries of the derrick or to the extent of any enclosure that is liable to trap gases.

11.6.3.4 Outdoor locations below the drill floor and within a radius of 3 m (10 ft) from a possible source of release (such as the top of the drilling nipple).

11.6.3.5 Areas within 1.5 m (5 ft) of the Zone 1 areas specified in 11.6.2.1.4 and areas within 1.5 m (5 ft) of the semi-enclosed locations specified in 11.6.2.1.2.

11.6.3.6 Outdoor areas within 1.5 m (5 ft) of the ventilation outlets from Zone 2 spaces.

11.6.3.7 Outdoor areas within 1.5 m (5 ft) of the access to Zone 1 spaces.

11.6.3.8 Semi-enclosed derricks to the extent of their enclosure above the drill floor or to a height of 3 m (10 ft) above the drill floor, whichever is greater.

11.6.3.9 Air locks between a Zone 1 space and an unclassified (non-hazardous) space.

11.7 DRILL FLOOR AND DERRICK AREAS

11.7.1 When the derrick is open at the drill floor level, the areas are classified as shown in Figure 67.

11.7.2 When a derrick is of the semi-enclosed open-top type, the areas are classified as shown in Figure 68.

11.7.3 An enclosed derrick is classified as shown in Figure 69.

11.7.4 For units with a movable or skidable drill floor and substructure, the classified area boundary should comply with the requirements of Figures 67, 68, and 69, as applicable, for the particular derrick operating position.

11.8 SUBSTRUCTURE OR MOONPOOL AREAS

11.8.1 MODUs with open substructures and semi-enclosed derricks are classified as shown in Figure 70.

11.8.2 MODUs with total containment substructures and semi-enclosed derricks are classified as shown in Figure 71.

Note: MODUs with total containment substructures are designed and constructed to prevent fluid discharges to the surrounding waters.

11.8.3 MODUs with semi-enclosed substructures and semi-enclosed derricks are classified as shown in Figure 72.

11.8.4 MODUs with enclosed moonpool areas are classified as shown in Figure 73.

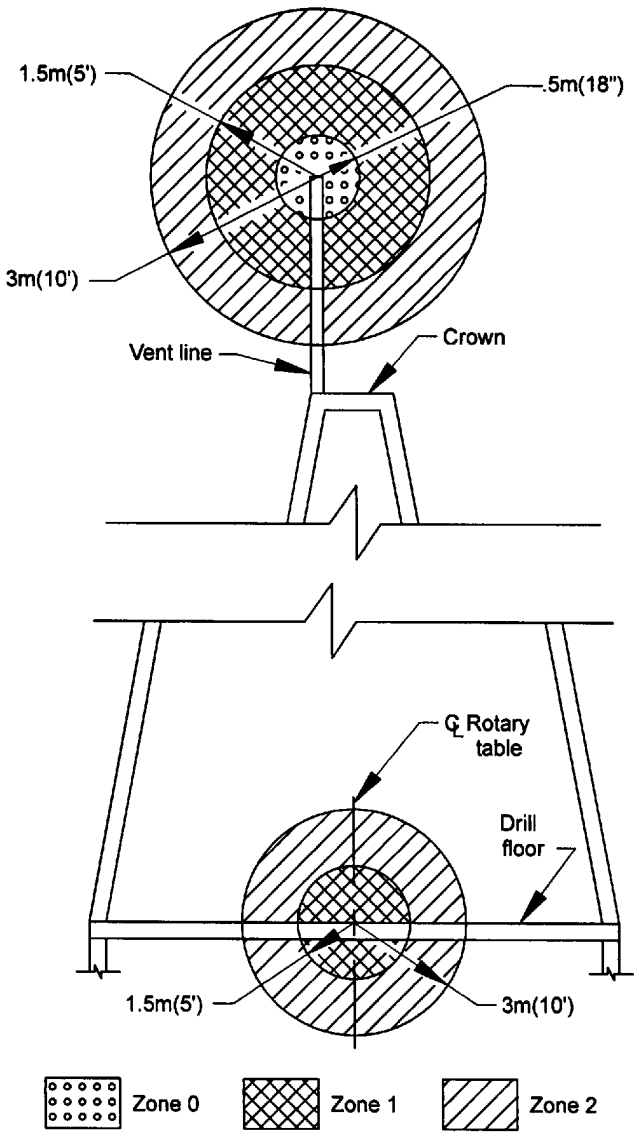
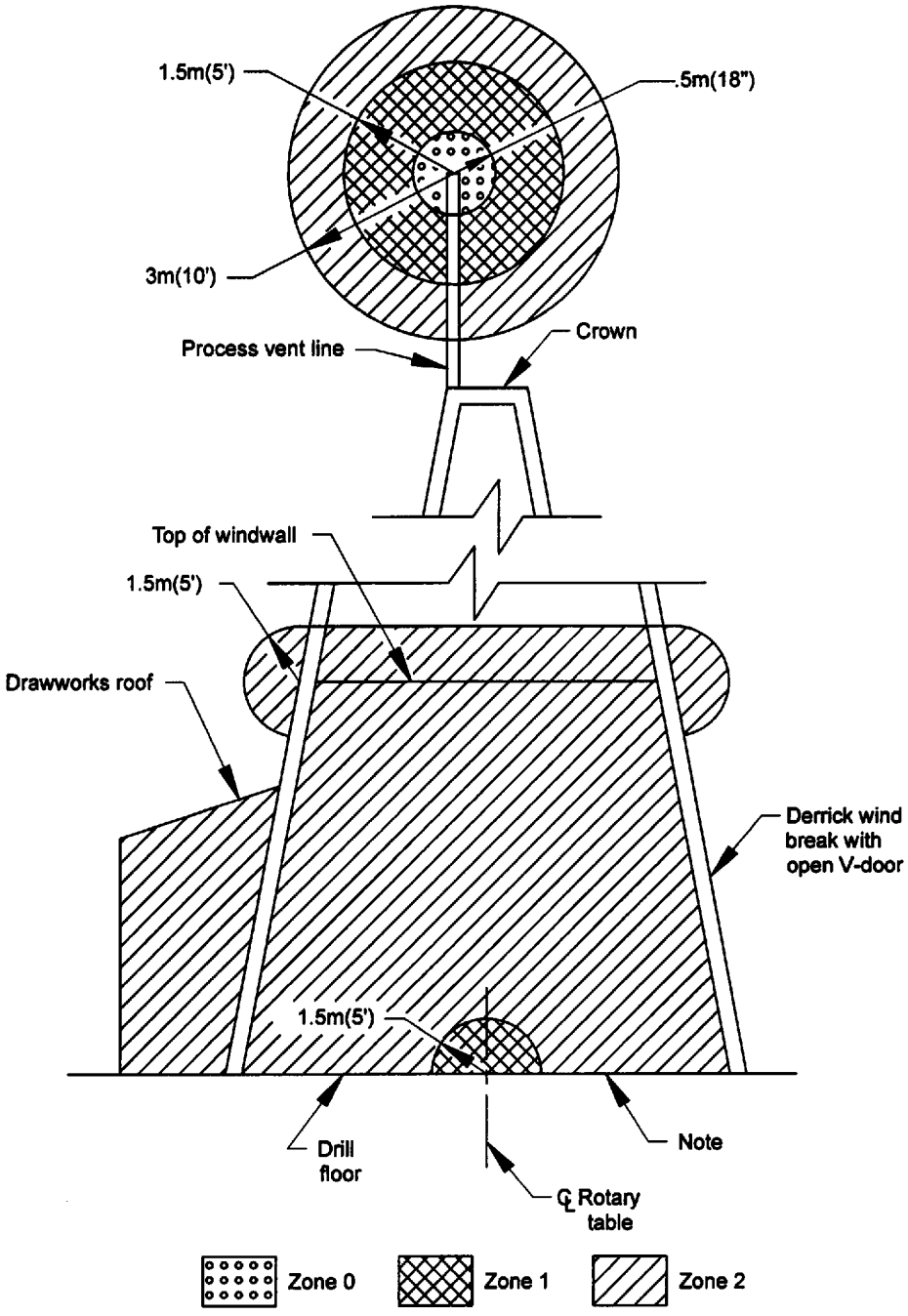


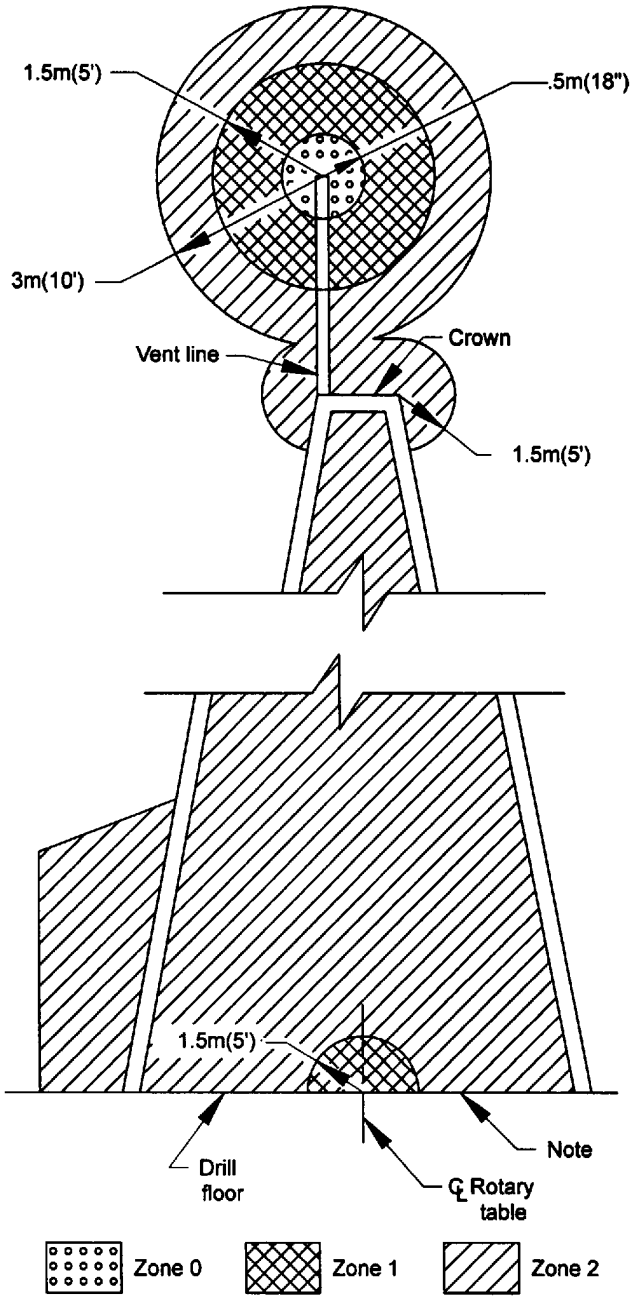
Figure 67—Drilling Rig Open Derrick
(See Section 11.7.1)



Note:

For classification below drill floor see applicable substructure diagrams.

Figure 68—Drilling Rig Semi-Enclosed Derrick
(See Section 11.7.2)



Note:

For classification below drill floor see applicable substructure diagrams.

Figure 69—Drilling Rig Derrick Fully Enclosed (Open Top)
(See Section 11.7.3)

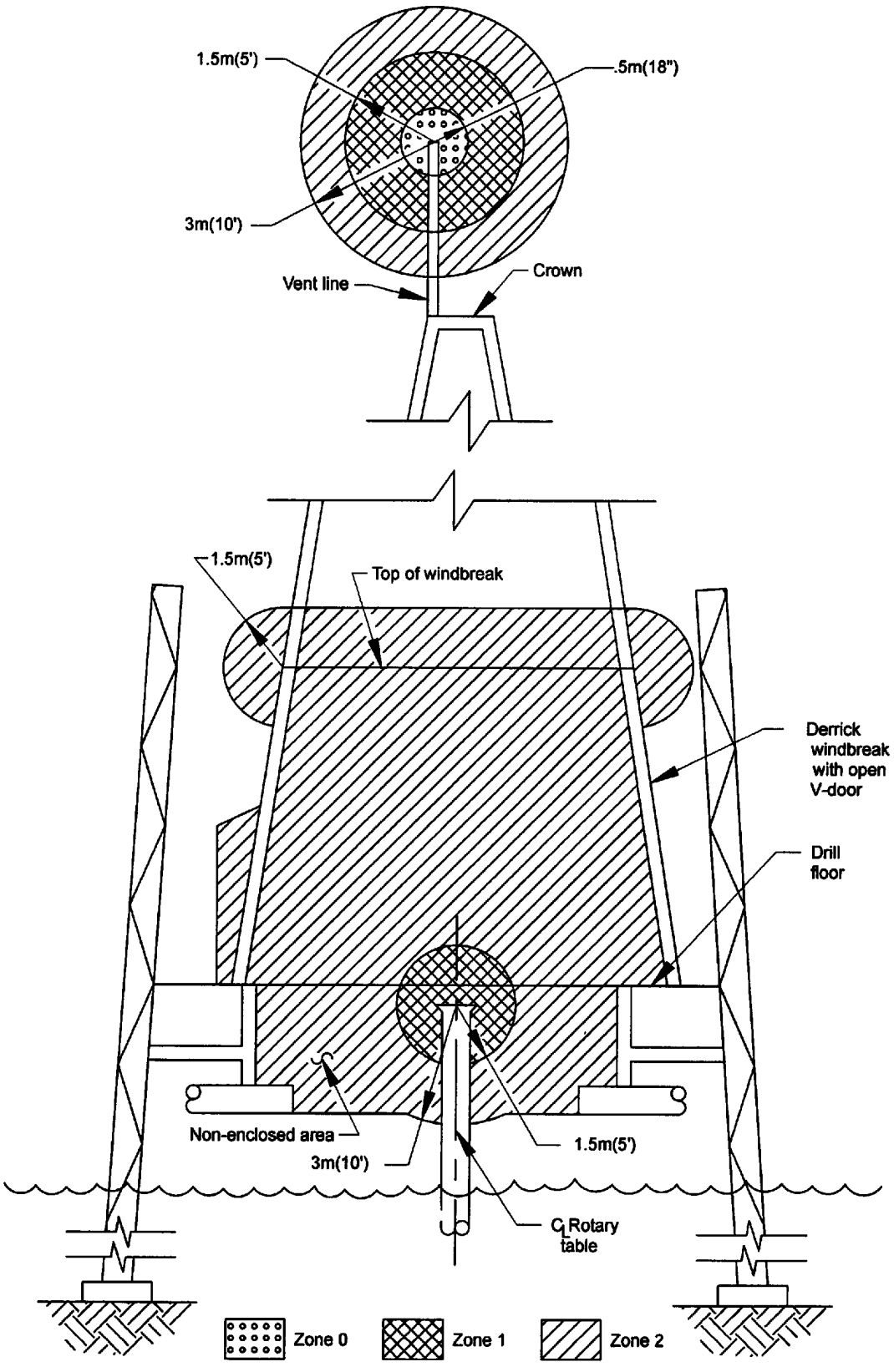


Figure 70—Drilling Rig Open Substructure and Semi-Enclosed Derrick
(See Section 11.8.1)

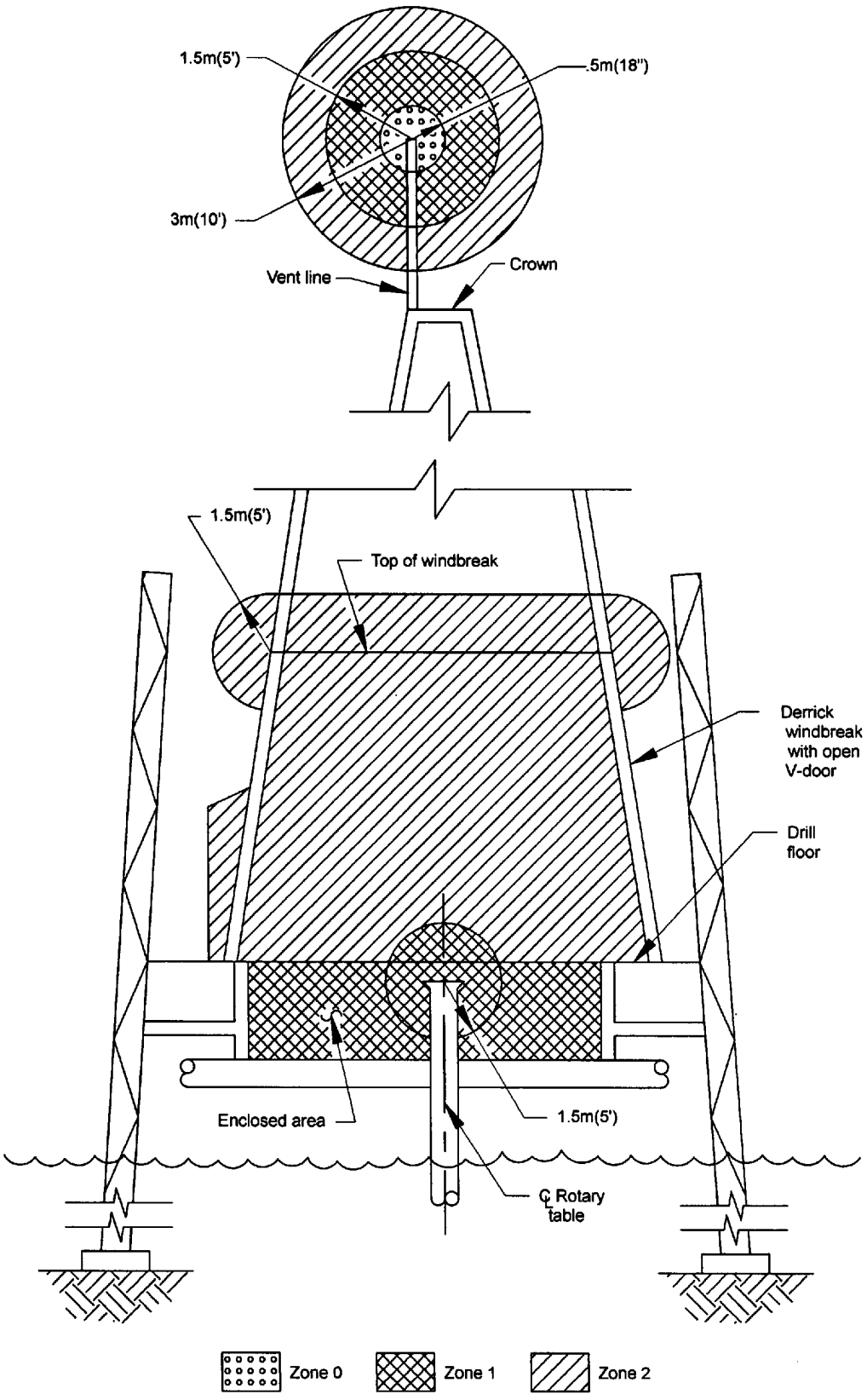


Figure 71—Drilling Rig With Total Containment Substructure and Semi-Enclosed Derrick Drilling Rig (See Section 11.8.2)

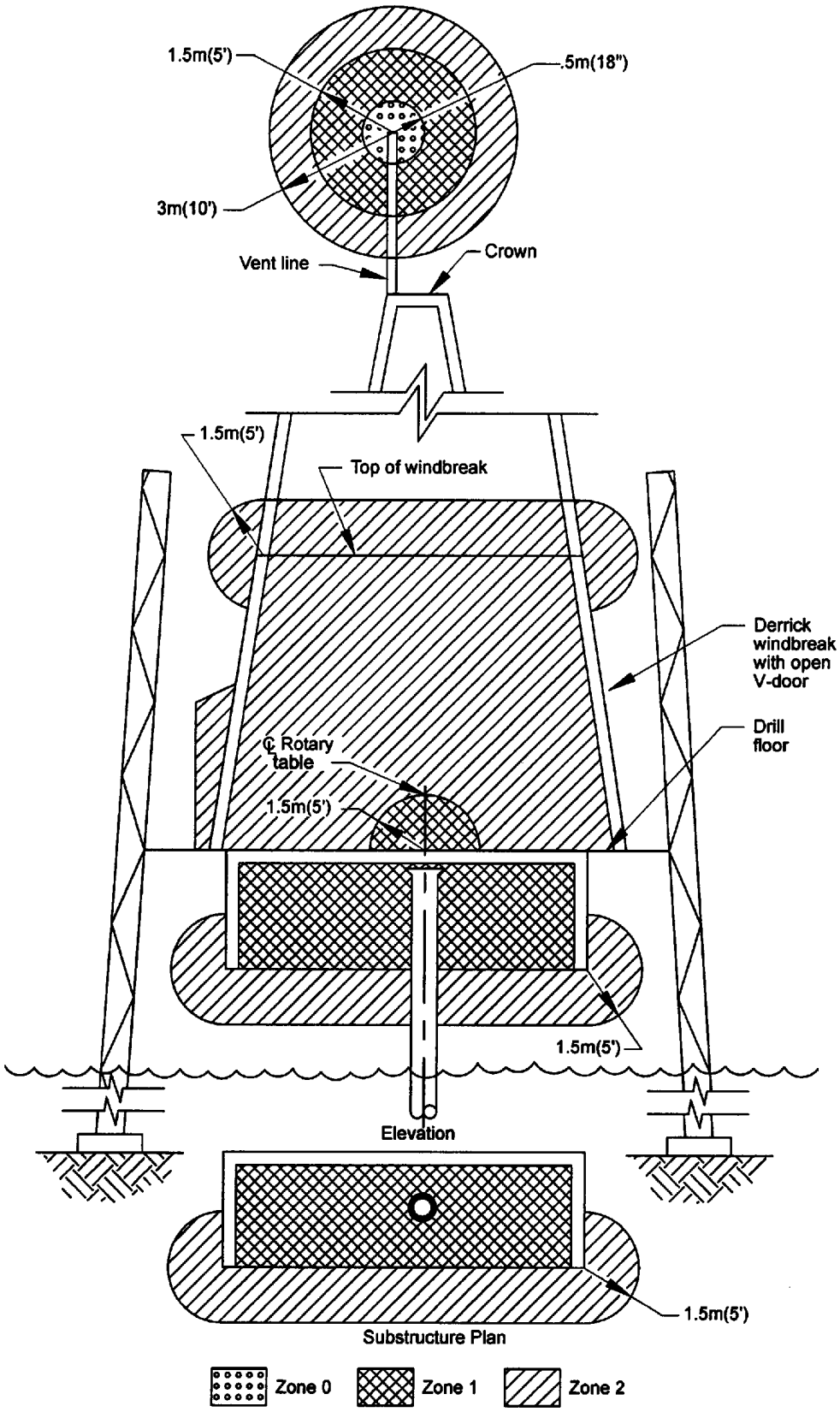


Figure 72—Semi-Enclosed Substructure and Semi-Enclosed Derrick
(See Section 11.8.3)

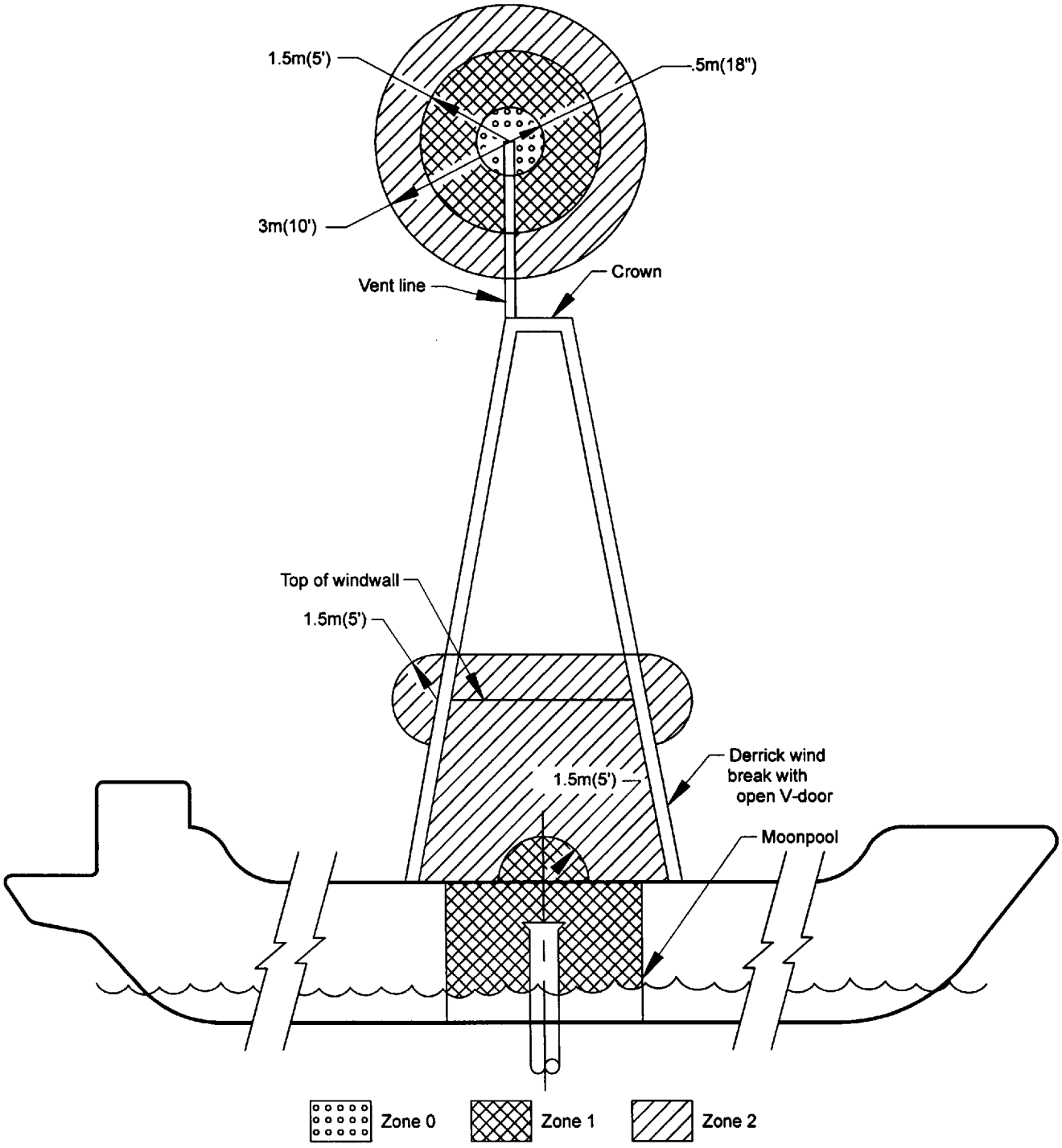


Figure 73—Drilling Rig Enclosed Moonpool and Semi-Enclosed Derrick
(See Section 11.8.4)

11.9 MUD SYSTEM PROCESSING EQUIPMENT OVERVIEW

11.9.1 Adequately ventilated enclosed spaces containing mud system processing equipment are classified as shown in Figure 74.

11.9.2 Open spaces containing mud system processing equipment are classified as shown in Figure 75.

11.10 MUD TANKS (AFTER DISCHARGE OF FINAL DEGASSER)

11.10.1 Open areas containing mud tanks are classified as shown in Figure 76.

11.10.2 Adequately ventilated enclosed or adequately ventilated semi-enclosed locations containing open top mud tanks are classified as shown in Figure 77.

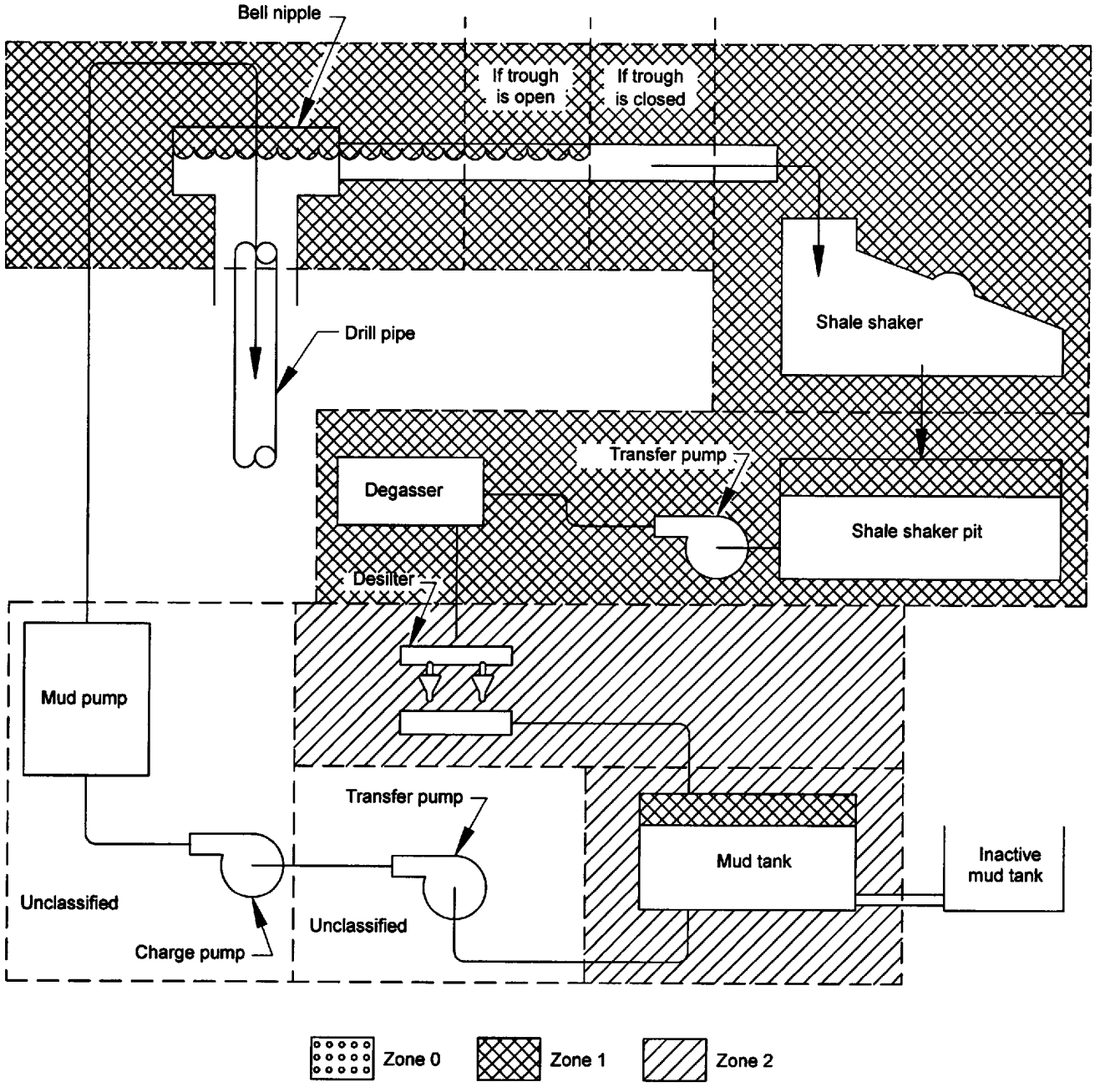
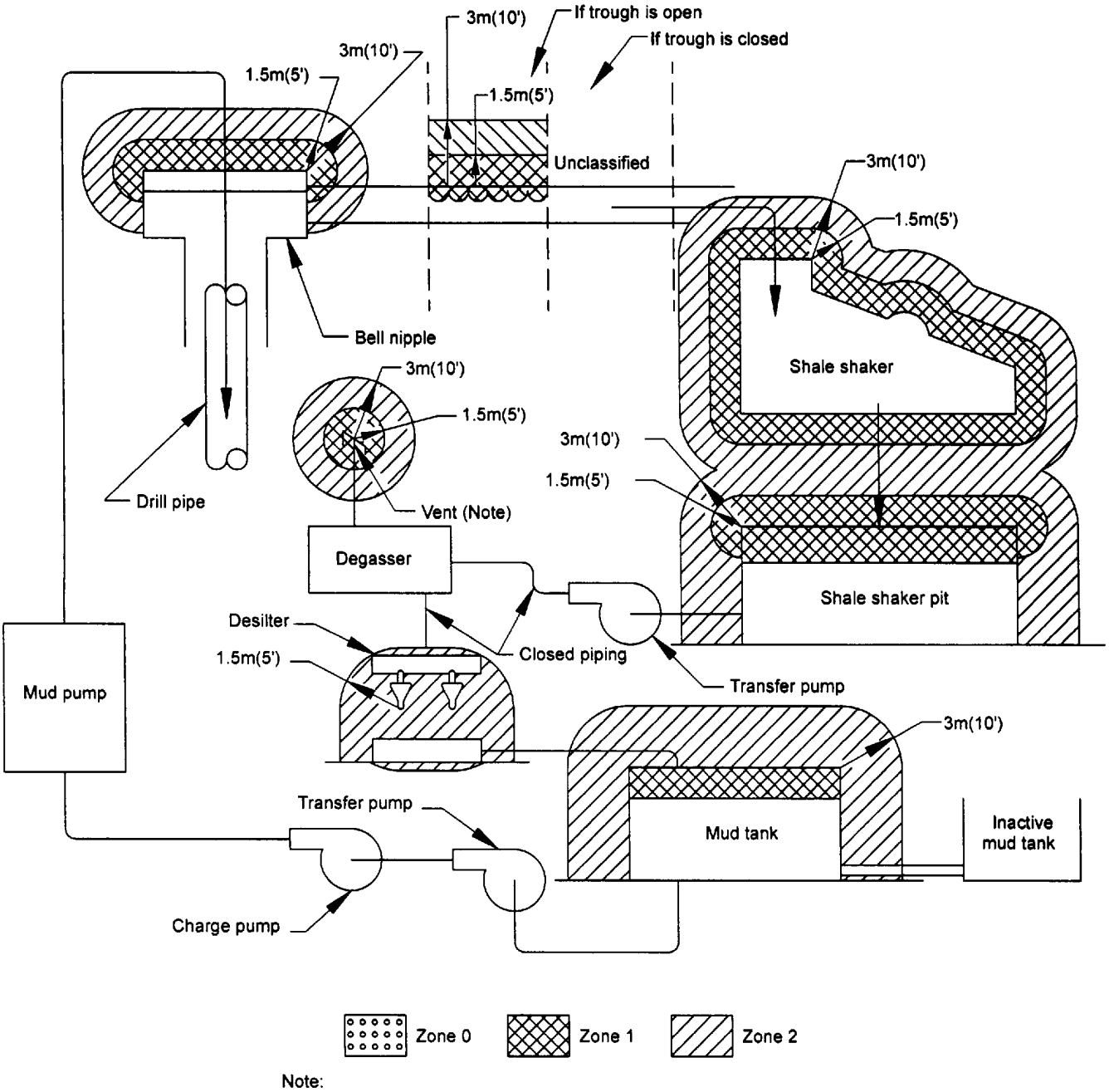


Figure 74—Mud System Processing Equipment in Adequately Ventilated Enclosed Spaces (See Section 11.9.1)



Note:

An area .5 meters (18") around the degasser vent is classified Zone 0.

Figure 75—Mud System Processing Equipment in Open Spaces
(See Section 11.9.2)

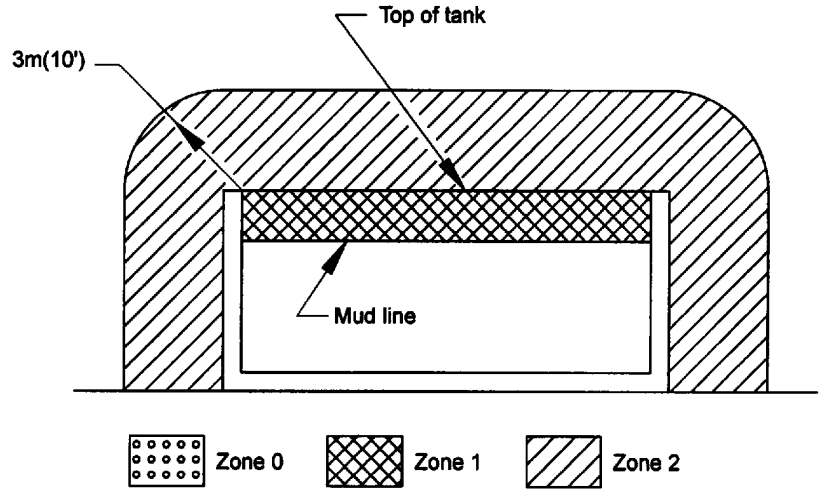


Figure 76—Mud Tanks in Open Areas
(See Section 11.10.1)

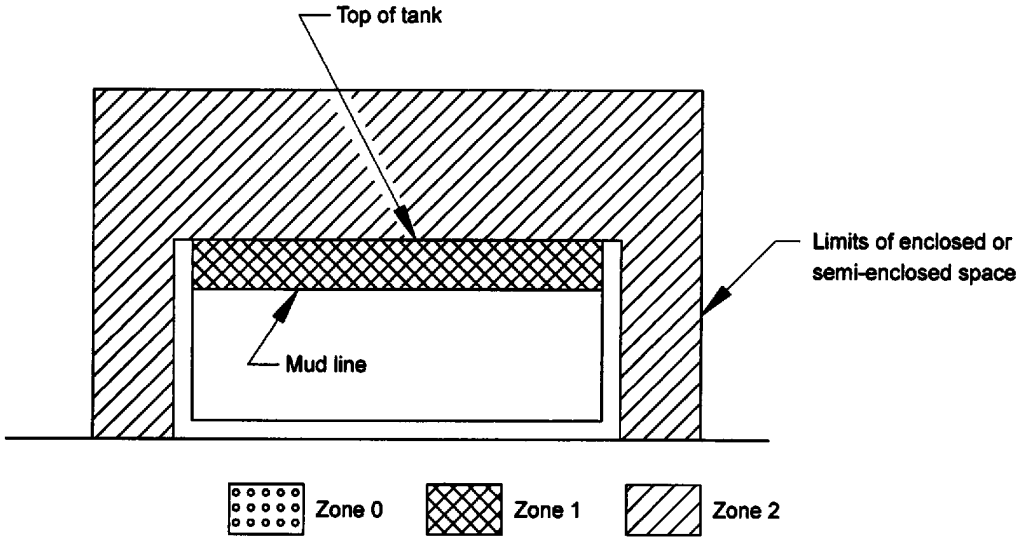


Figure 77—Open Top Mud Tanks in Enclosed or Semi-Enclosed Locations With Adequate Ventilation
(See Section 11.10.2)

11.10.3 Adequately ventilated enclosed or adequately ventilated semi-enclosed locations containing closed top mud tanks are classified as shown in Figure 78.

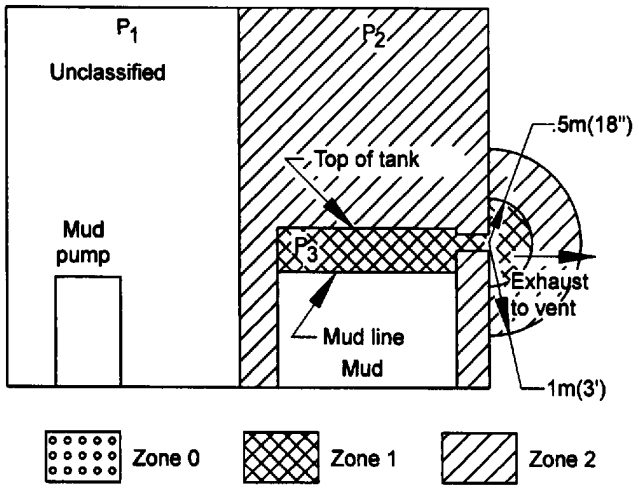
11.11 MUD DITCHES OR TROUGHS

11.11.1 For classification of locations containing a mud ditch or trough, refer to Figure 79, 80, 81, or 82, as applicable.

11.12 MUD PUMPS

11.12.1 Spaces containing mud pumps with totally enclosed piping do not require classification.

Note: Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.



Notes:

P_1 Pressure is greater than P_2 pressure

P_2 Pressure is greater than P_3 pressure

Differential pressure between zones must be a minimum of 25 Pa (0.1 in. H_2O).

Figure 78—Closed Top Mud Tanks in Enclosed or Semi-Enclosed Locations With Adequate Ventilation (See Section 11.10.3)

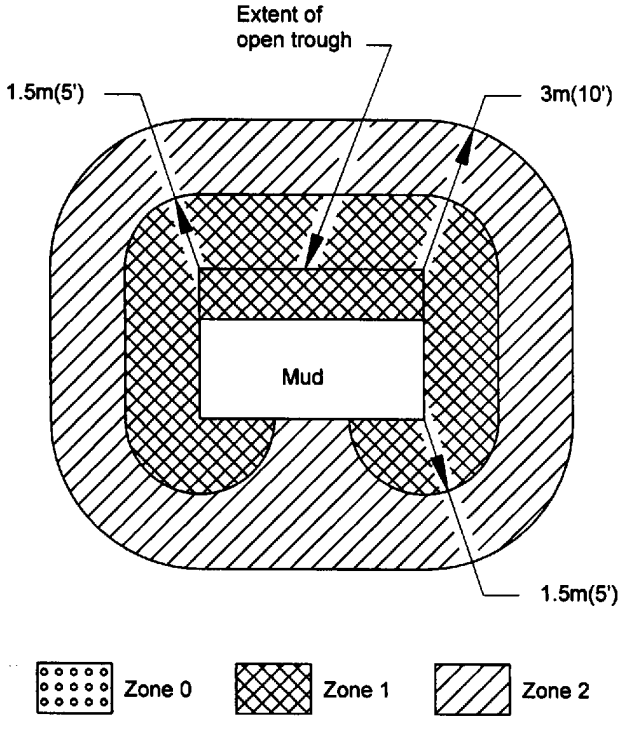


Figure 79—Open Mud Trough in Open Space Before Degasser (See Section 11.11.1)

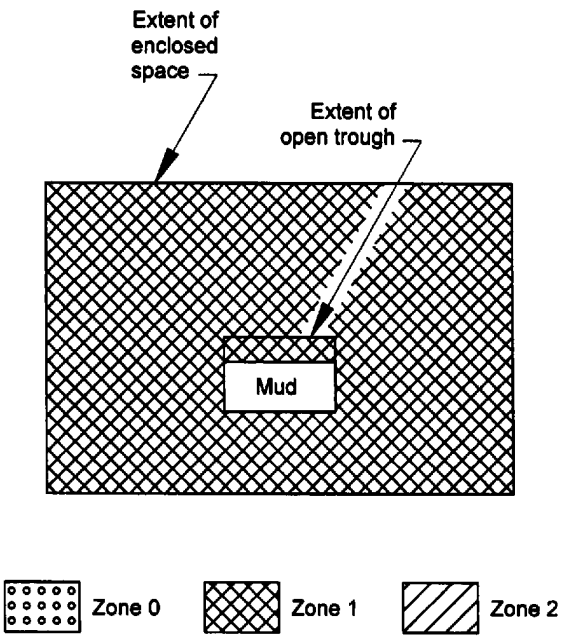


Figure 80—Open Mud Trough in Enclosed Space With Adequate Ventilation Before Degasser (See Section 11.11.1)

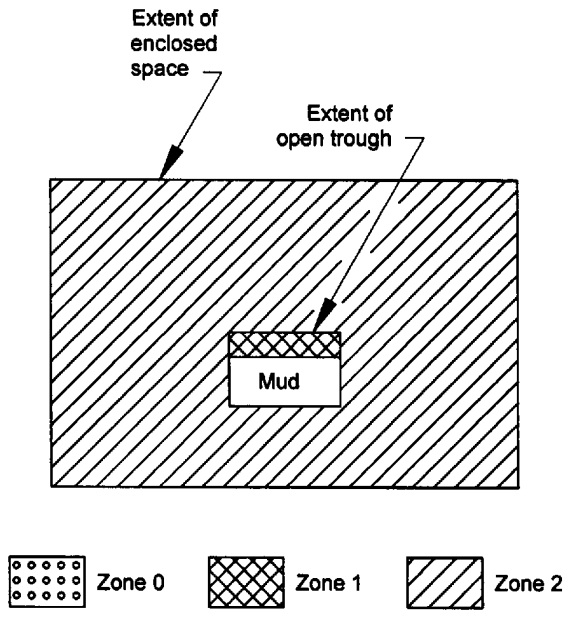


Figure 81—Open Mud Trough in Enclosed Space With Adequate Ventilation Downstream of Degasser (See Section 11.11.1)

11.13 MUD PROCESSING EQUIPMENT (BETWEEN THE BELL NIPPLE AND MUD DISCHARGE OF FINAL DEGASSER)

11.13.1 Adequately ventilated enclosed or adequately ventilated semi-enclosed spaces containing a shale shaker are classified as shown in Figure 83.

11.13.2 Open areas containing a shale shaker are classified as shown in Figure 84.

11.14 DESANDER OR DESILTER (BETWEEN MUD DISCHARGE OF FINAL DEGASSER AND THE MUD PIT)

11.14.1 Adequately ventilated enclosed or adequately ventilated semi-enclosed spaces containing a desander or desilter are classified as shown in Figure 85.

11.14.2 Open areas containing a desander or desilter are classified as shown in Figure 86.

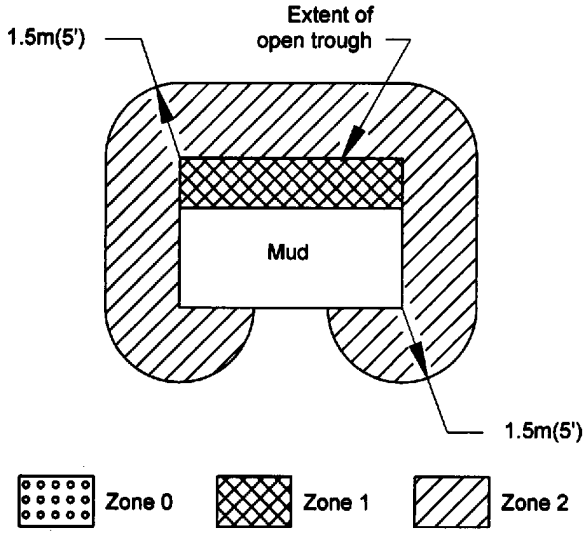


Figure 82—Open Mud Trough in Open Space Downstream of Degasser (See Section 11.11.1)

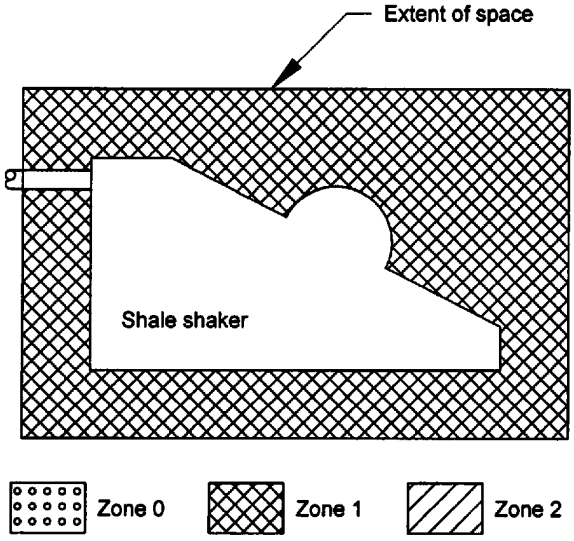


Figure 83—Shale Shaker in Enclosed or Semi-Enclosed Space With Adequate Ventilation (See Section 11.13.1)

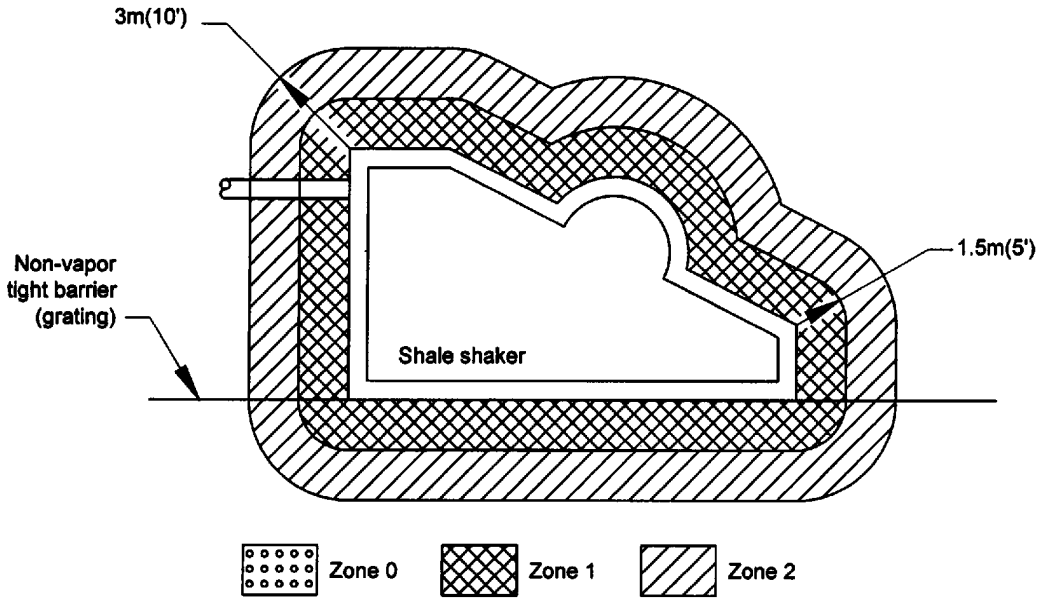


Figure 84—Shale Shaker in Open Area With Adequate Ventilation (See Section 11.13.2)

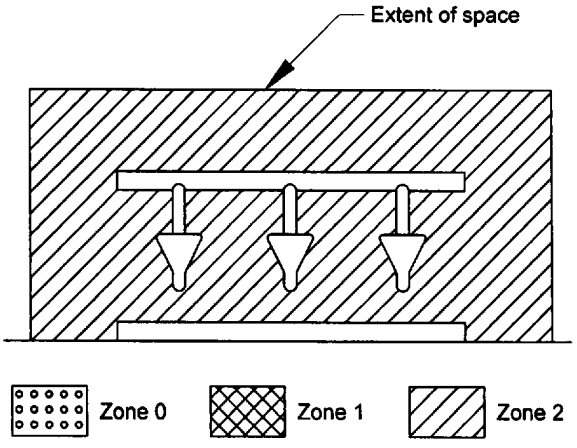


Figure 85—Desander or Desilter in Enclosed or Semi-Enclosed Space With Adequate Ventilation (See Section 11.14.1)

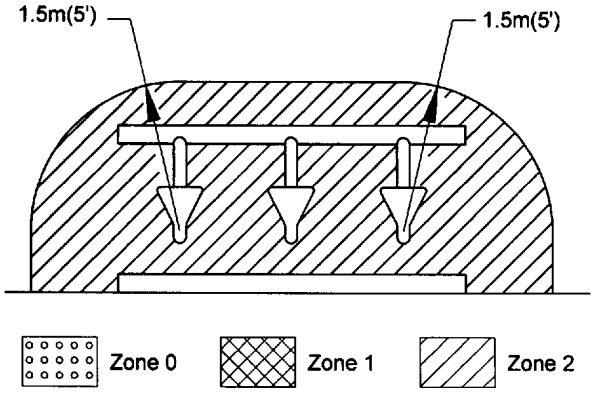


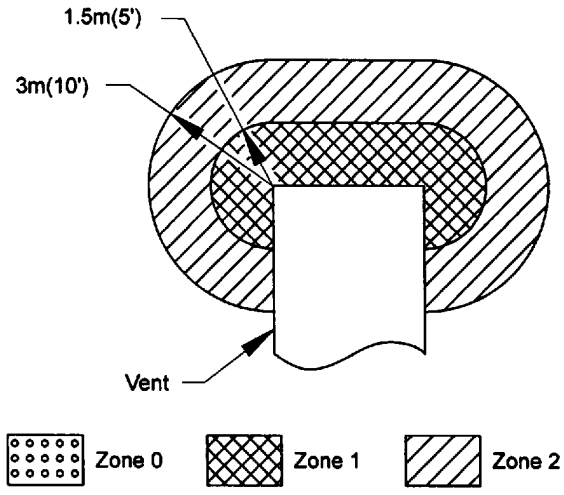
Figure 86—Desander or Desilter in Open Area (See Section 11.14.2)

11.15 VENTS

11.15.1 Areas containing discharges of ventilation vents originating in Zone 0 areas should be classified in a manner similar to that shown in Figure 87, except they should be surrounded by a Zone 0 classification for a distance of 0.5 m (18 in). The Zone 0 classification should be surrounded by a Zone 1 classification for a distance of 1 m (3 ft), which, in turn, should be surrounded by a Zone 2 classification of 1.5 m (5 ft).

11.15.2 Areas containing discharges of ventilation vents originating in Zone 1 areas and equipment vents (such as degasser vents) should be classified as shown in Figure 87.

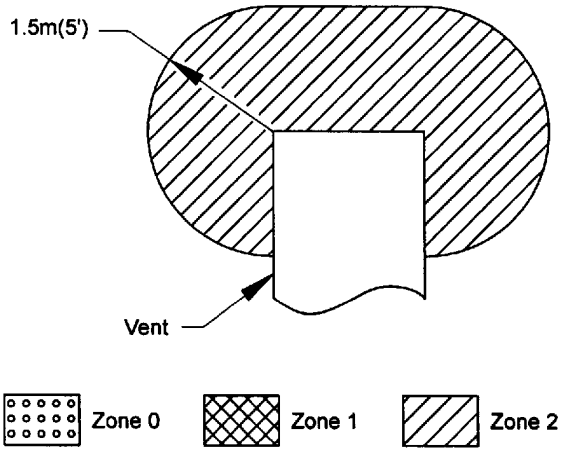
11.15.3 Areas containing discharges of ventilation vents originating in Zone 2 areas should be classified as shown in Figure 88.



Note:

The interior of the vent piping is Zone 1. Cross hatching has been omitted for drawing clarity.

Figure 87—Discharges of Ventilation Vents and Equipment Vents Originating in Zone 1 Areas (See Sections 11.15.1 and 11.15.2)



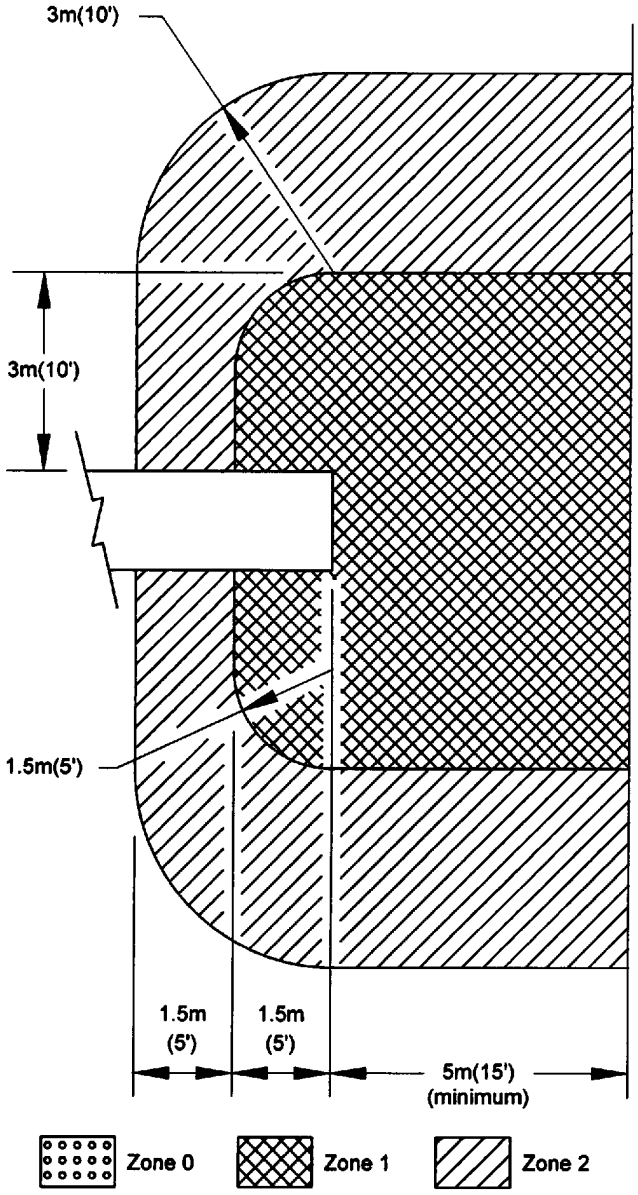
Note:

The interior of the vent piping is Zone 2. Cross hatching has been omitted for drawing clarity.

Figure 88—Discharges of Ventilation Vents and Equipment Vents Originating in Zone 2 Areas (See Section 11.15.3)

11.16 DIVERTER LINE OUTLET

11.16.1 The criteria for the classification of the area surrounding a diverter line outlet are too diverse to specify distances. Individual sound engineering judgment is required for specific cases, but in no case should the classification be less than shown in Figure 89. Refer to API RP 521.



Note:

The interior of the vent piping is Zone 1.Cross hatching has been omitted for drawing clarity.

Figure 89—Diverter Line Outlet
(See Section 11.16.1)

11.17 BLOWOUT PREVENTER (BOP)

Open locations containing BOPs do not require classification.

Note Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.

11.18 WELL TEST EQUIPMENT AREAS

The degree and extent of classified locations for well test equipment on MODUs should be the same as recommended by Section 10 for similar production equipment.

11.19 ROOMS USED TO STORE PAINT (PAINT LOCKERS)

11.19.1 The interior of enclosed spaces used for the storage of flammable paint (i.e., paint lockers) should be classified Class I, Zone 1.

11.20 BATTERY ROOMS

Locations containing batteries should be classified in accordance with Section 8.2.6.

Note: Authorities having jurisdiction may require special considerations for electrical equipment installed in such locations.

11.21 RESERVED FOR FUTURE USE

11.22 HELICOPTER FUEL STORAGE AREAS

11.22.1 Helicopter fuel storage areas should be classified in accordance with Section 8.2.1.3.1.

11.23 CLASSIFICATION OF ADJACENT SPACES

11.23.1 General. Openings, access and ventilation conditions affect the extent of hazardous (classified) locations.

11.23.1.1 Where an access door or other opening provides direct access from a hazardous (classified) location (Zone 0, Zone 1, or Zone 2) to an enclosed space, the enclosed space should be classified the same as that classified location, with the following exceptions:

11.23.1.1.1 An enclosed space with direct access to a Zone 1 location can be considered as Zone 2 provided all the following criteria are met:

11.23.1.1.1.1 The access is fitted with an inward opening, self-closing, vapor-tight door with no hold-back provisions;

11.23.1.1.1.2 the ventilation is such that the air flow with the door open is from the Zone 2 space into the Zone 1 space (see Section 11.5.2.1); and

11.23.1.1.1.3 the loss of ventilation is alarmed at a manned station, and corrective action is initiated to restore ventilation.

11.23.1.1.2 An enclosed space with direct access to a Zone 2 location can considered unclassified (non-hazardous) provided all the following criteria are met:

11.23.1.1.2.1 The access is fitted with an inward opening, self-closing, vapor-tight door with no holdback provisions;

11.23.1.1.2.2 the ventilation is such that the air flow with the door open is from the unclassified space into the Zone 2 location (see Section 11.5.2.1); and

11.23.1.1.2.3 the loss of ventilation is alarmed at a manned station and corrective action is initiated to restore ventilation.

11.23.1.1.3 An enclosed space with direct access to a Zone 1 location can be considered unclassified provided all the following criteria are met.

11.23.1.1.3.1 The access is fitted with two self-closing, vapor-tight doors with no hold-back provisions, forming an air lock between the two doors;

11.23.1.1.3.2 the ventilation is such that the air flow with the door open is from the unclassified space into the classified space (see Section 11.5.2.1); and

11.23.1.1.3.3 the loss of ventilation (over-pressure) is alarmed at a manned station and corrective action is initiated to restore ventilation.

11.23.1.1.3.4 Air locks between a Zone 1 location and an unclassified location should be classified as Zone 2.

12 Recommendations for Determining Degree and Extent of Classified Locations at Drilling Rigs and Production Facilities on Floating Production Units

12.1 GENERAL

12.1.1 This section presents guidelines for classifying locations for electrical installations at locations surrounding oil and gas drilling and workover rigs and facilities on floating production units where flammable liquids, gases or vapors are produced, processed, stored, transferred, or otherwise handled prior to entering the transportation facilities.

12.1.1.1 The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered in producing and drilling operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing information presented in this recommended practice and other publications. Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.

12.1.1.2 High pressures and potentially large releases may justify greater dimensions for classified locations than those shown.

12.1.1.3 The classification of locations surrounding oil and gas drilling and workover rigs and production facilities external to the hull should be in accordance with Sections 1 through 8, Section 10, and the appendixes of this document are applicable except as noted in this section.

12.1.1.4 Locations containing batteries should be classified in accordance with Section 8.2.6.

Note: Authorities having jurisdiction may require special considerations for electrical equipment installed in such locations.

12.2 FLOATING PRODUCTION STORAGE AND OFFLOADING UNITS (FPSOS)

12.2.1 The area classification of a Floating Production Storage and Offloading unit (FPSO) or similar unit is classified as shown in Figure 90.

12.3 TENSION LEG PLATFORMS (TLPS)

The area classification of a tension leg platform (TLP) or similar unit is classified as shown in Figure 91.

12.4 SPARS, CAISSONS, AND SIMILAR UNITS

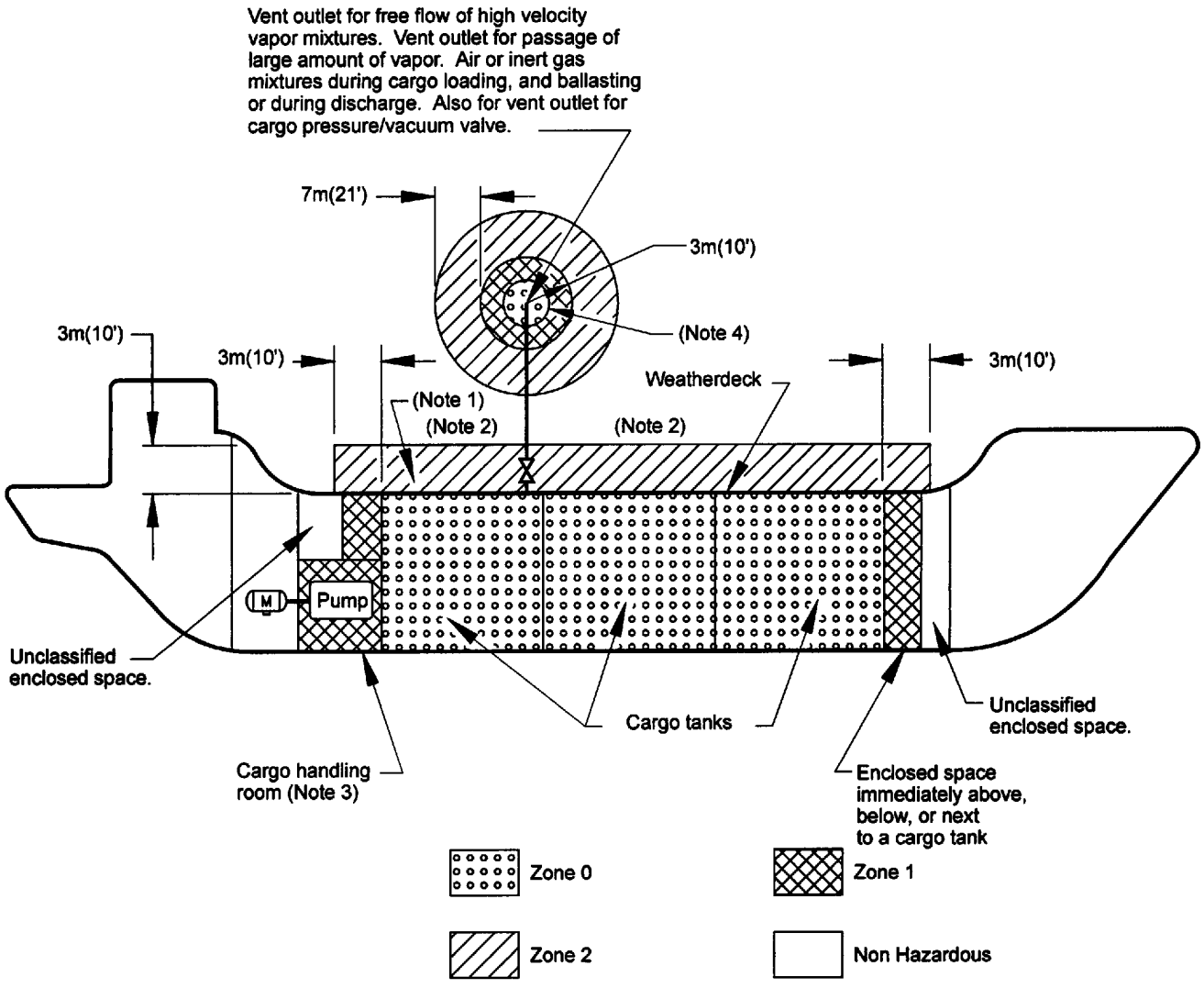
12.4.1 The area classification of the moonpool and other areas of spar, caisson, and similar units whose moonpool contains hydrocarbon production risers, drilling risers, and pipelines containing no flanges, valves, etc. is classified as shown in Figure 92.

12.4.2 The area classification of the moonpool and other areas of spar, caisson, and similar units whose moonpool contains hydrocarbon production risers, drilling risers, and pipelines containing flanges, valves, and similar devices is classified Class I, Zone 1.

12.5 CLASSIFICATION OF ADJACENT SPACES

12.5.1 General. Openings, access provisions and ventilation conditions affect the extent of hazardous (classified) locations.

12.5.2 Where an access door or other opening provides direct access from a hazardous (classified) location (Zone 1 or Zone 2) to an enclosed space, the enclosed space should be classified the same as that classified location, with the following exceptions:

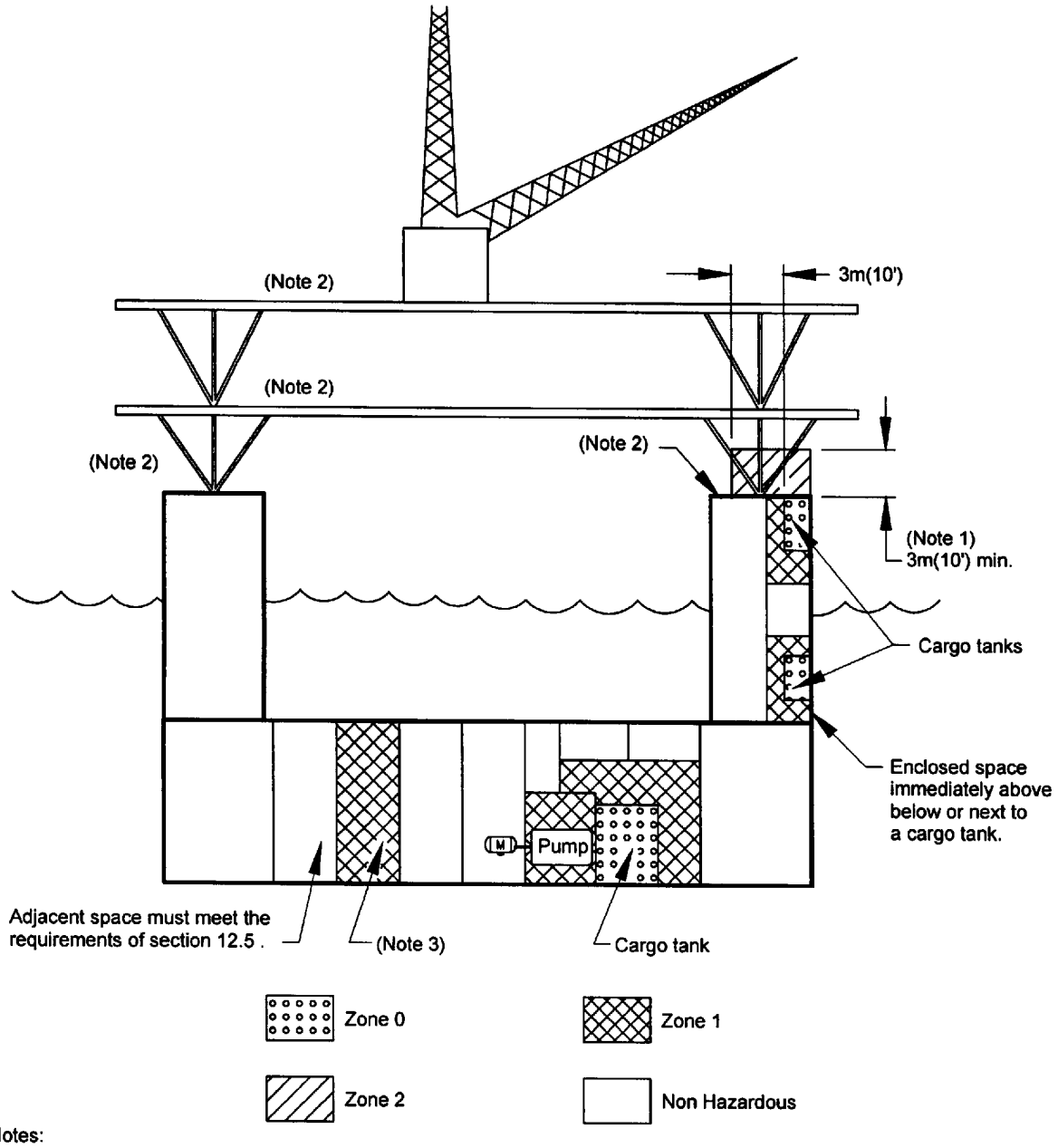


Notes:

1. This area classified due to proximity to cargo tanks.
2. Areas more than 3m(10') above the weatherdeck are unclassified except as required by this document for production equipment contained therein.
3. Space must be:
   a) continuously ventilated at ≥ 20 air changes per hour, and
   b) loss of ventilation must be alarmed in a manned space, and
   c) combustible gas detection must be installed in accordance with section 6.5.2 .

   or, If ventilated <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.
4. An area 1 meter (3 feet) around vent is classified Zone 0.

Figure 90—Typical Floating Production Storage and Offloading Unit (FPSO)
(See Section 12.2.1)



Notes:

1. This area classified due to proximity to cargo tanks.

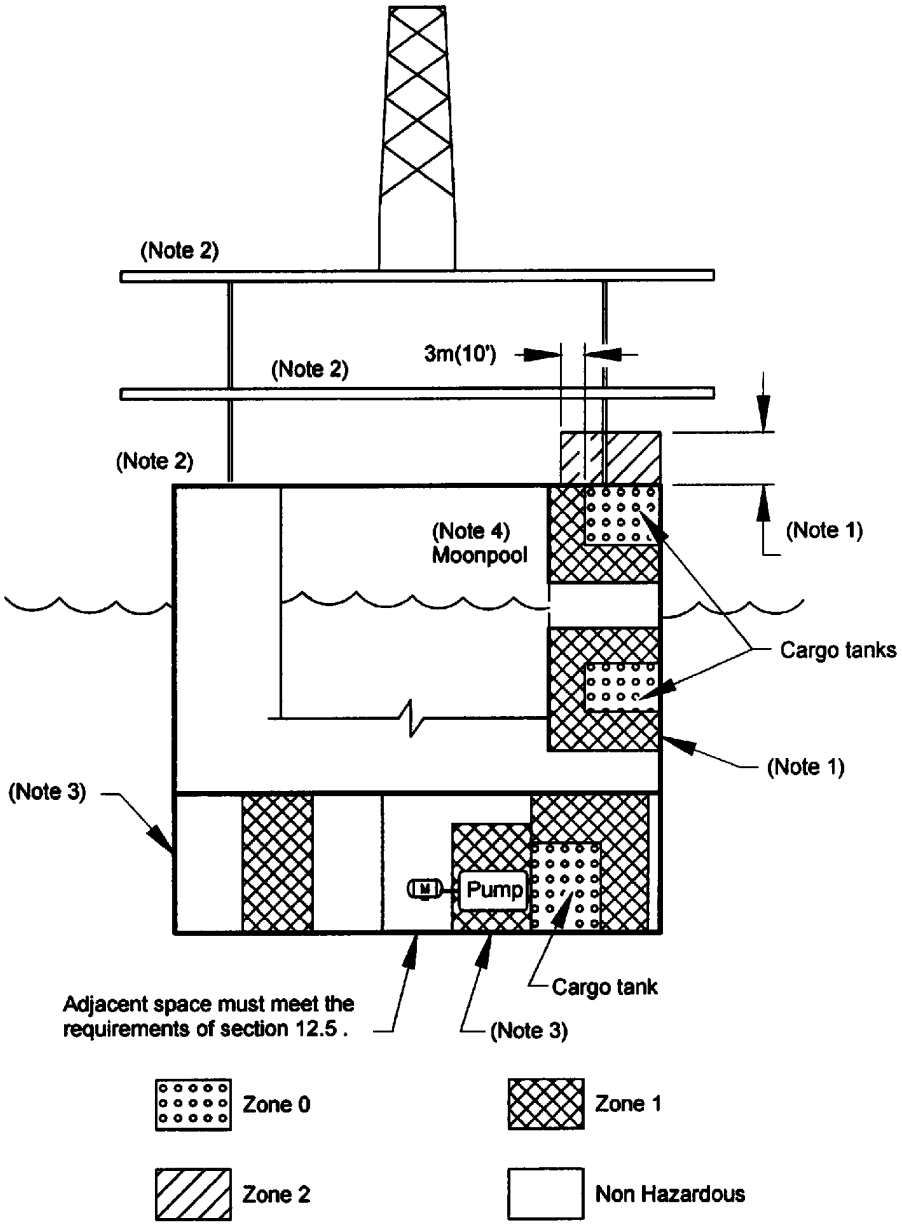
2. Areas more than 3m(10') above the weatherdeck are unclassified except as required by this document for production and drilling equipment contained therein.

3. Space containing processing equipment or natural gas fueled prime mover with all flammable liquid or gas vents extended to the outside the area are classified Zone 1 if:

   a) continuously ventilated at ≥20 air changes per hour, and
   b) loss of ventilation must be alarmed in a manned space, and
   c) combustible gas detection must be installed in accordance with section 6.5.2 .

   or, If ventilated <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.

Figure 91—Typical Tension Leg Platform (TLP)
(See Section 12.3)



Notes:

1. This area classified due to proximity to cargo tanks.
2. Areas more than 3m(10') above the weatherdeck are unclassified except as required by this document for production and drilling equipment contained therein.
3. Space containing processing equipment or natural gas fueled prime mover with all flammable liquid or gas vents extended to the outside the area are classified Zone 1 if:
   a) continuously ventilated at ≥ 20 air changes per hour, and
   b) loss of ventilation must be alarmed in a manned space, and
   c) combustible gas detection must be installed in accordance with section 6.5.2 .

   or, If ventilated <20 air changes per hour, loss of ventilation is not alarmed, or gas detectors are not installed, then the area is classified Zone 0.
4. Moonpool area is unclassified if it contains all welded closed piping or continuous metallic tubing systems without valves, flanges or similar devices, and is not within the hazardous area created by adjacent equipment.

Figure 92—Typical Spar, Caisson, or Similar Unit
(See Section 12.4.1)

12.5.2.1 An enclosed space with direct access to a Zone 1 location can be considered as Zone 2 provided the following criteria are met:

12.5.2.1.1 The access is fitted with an inward opening, self-closing, vapor-tight door with no hold-back provisions;

12.5.2.1.2 the ventilation is such that the air flow with the door open is from the Zone 2 space into the Zone 1 space (see Section 11.5.2.1); and

12.5.2.1.3 the loss of ventilation is alarmed at a manned station and corrective action is initiated to restore ventilation.

12.5.2.2 An enclosed space with direct access to a Zone 2 location can considered unclassified (non-hazardous) provided the following criteria are met:

12.5.2.2.1 The access is fitted with an inward opening, self-closing, vapor-tight door with no holdback provisions;

12.5.2.2.2 the ventilation is such that the air flow with the door open is from the unclassified (non-hazardous) space into the Zone 2 location (see Section 11.5.2.1); and

12.5.2.2.3 the loss of ventilation is alarmed at a manned station and corrective action is initiated to restore ventilation.

12.5.2.3 An enclosed space with direct access to a Zone 1 location can be considered unclassified provided the following criteria are met:

12.5.2.3.1 The access is fitted with two self-closing, vapor-tight doors with no hold-back provisions, forming an air lock between the two doors;

12.5.2.3.2 the ventilation is such that the air flow with the door open is from the unclassified space into the classified space (see Section 11.5.2.1); and

12.5.2.3.3 the loss of ventilation (over-pressure) is alarmed at a manned station and corrective action is initiated to restore ventilation.

12.5.2.3.4 Air locks between a Zone 1 location and an unclassified location should be classified as Class 1, Zone 2.

13 Reserved for Future Use

14 Recommendations for Determining Degree and Extent of Classified Locations at Petroleum Pipeline Transportation Facilities

14.1 GENERAL

14.1.1 This Section presents guidelines for classifying locations for electrical installations at pipeline transportation facilities. The guidelines cover onshore and offshore pipeline facilities handling flammable and combustible liquids and flammable gases and vapors. Pipeline facilities may include pump and compressor stations, storage facilities, manifold areas, and valve sites.

14.1.2 The following recommendations for determining the degree and extent of classified locations are specific examples of situations commonly encountered in pipeline operations and have been developed by experience in the industry. Application of these examples to similar, though not identical, situations should be made with sound engineering judgment, employing information presented in this recommended practice and other publications. Specific examples listed consider only the item discussed and do not take into account the possible influence of adjacent areas classified due to other equipment.

14.1.3 High pressures, potentially large releases, and the presence of HVLs may justify greater dimensions for classified locations than those shown.

14.1.4 Pipeline facilities are frequently operated by remote control without full time local attendance. This practice was one of the factors considered in developing the classification guidelines. For this reason, some of the guidelines presented are more conservative than other API and NFPA guidelines for similar facilities in other segments of the petroleum industry.

14.2 USE OF FIGURES

14.2.1 The figures show classified locations surrounding typical sources of flammable liquids, vapors and gases. Some of the illustrations apply to a single source; others apply to an enclosed area or to an operating facility. The intended use of these figures is to develop area classification drawings. Elevations or sections will be required where different classifications apply at different elevations.

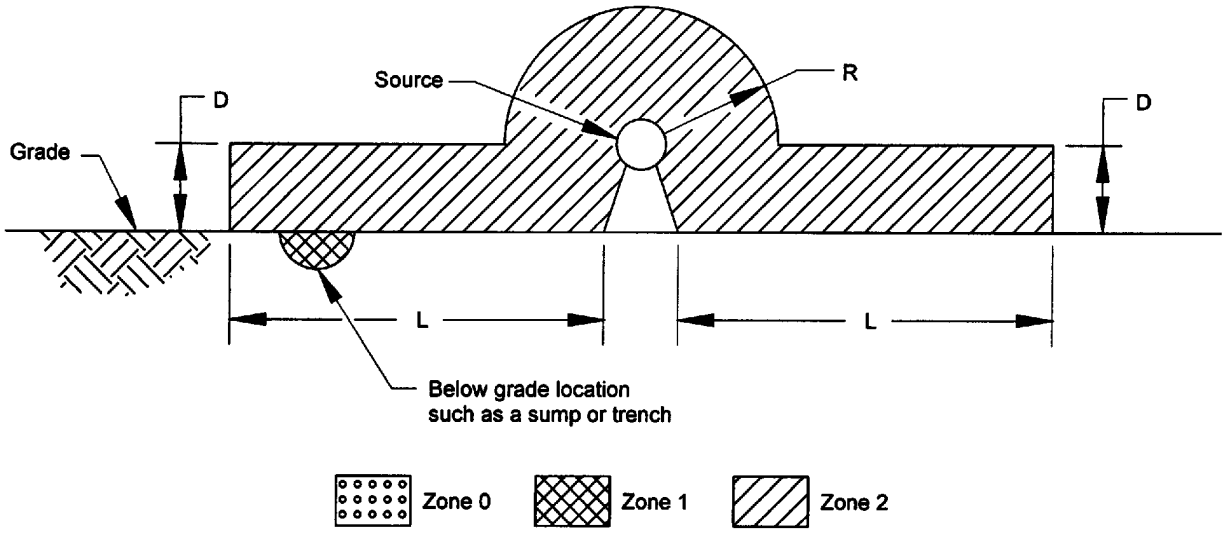
14.2.2 A pipeline location may have many interacting sources of flammable liquid, vapor or gas, including pumps, compressors, manifolds, sampling stations, meters, operating and control valves. Accordingly, sound engineering judgment is required to set the boundaries for electrical area classification.

14.2.3 Use Section 14.3, to select the figure or figures that apply to each source or condition. Determine the applicable Zones, their extent, and their layout, considering the local environmental conditions. It is recommended that a layout be made of each classified location, based on the interaction of individual sources described in 14.2.2.

14.2.4 It may be found that individual classification of a great number of sources in a location is not feasible. Classification of an entire building or location as a single area should be considered after evaluation of the extent and interaction of various sources and areas within, or adjacent to, the location.

14.3 FIGURES

14.3.1 Figures 93 through 95 show classified locations around a pump or compressor handling flammable liquids or highly volatile liquids.

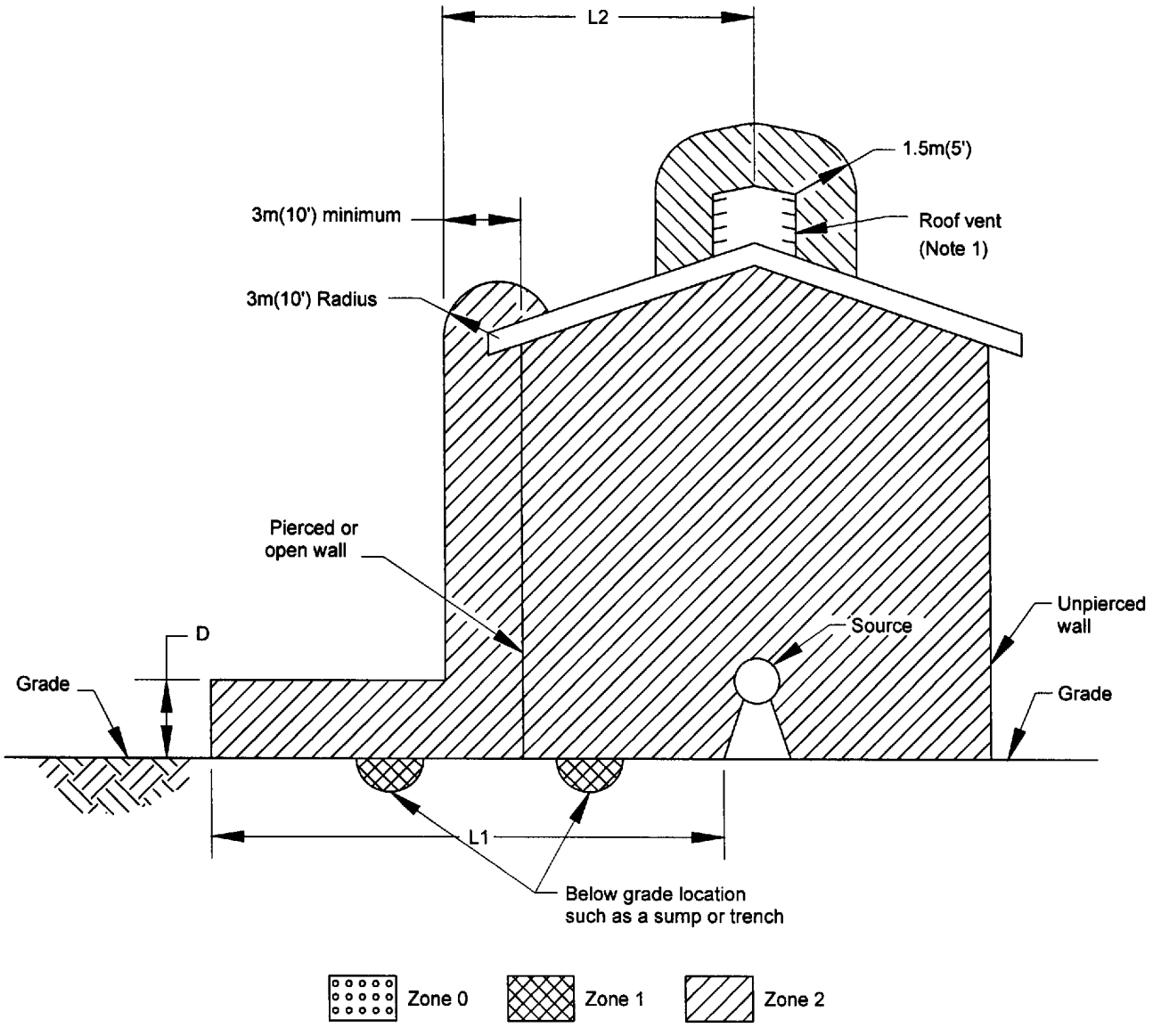


Level	Distance in meters(feet)		
	L	R	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	1(3)	.6(2)
2. Liquid above 1900 kPa (275 PSIG) (Note 1)	15(50)	7.5(25)	.6(2)
3. HVL (Note 2)	30(100)	7.5(25)	.6(2)

Notes:

1. Level 1 dimensions may be used for small pumps operating above 1900 kPa (275 PSIG) where leakage is likely to be small. Pipeline gathering pumps would normally be included in this exception.
2. Dimension L may be reduced to no less than 15 meters (50 feet) where leakage is likely to be small.

Figure 93—Outdoors—Pump or Compressor Handling Flammable Liquids or Highly Volatile Liquids (See Section 14.3.1.)

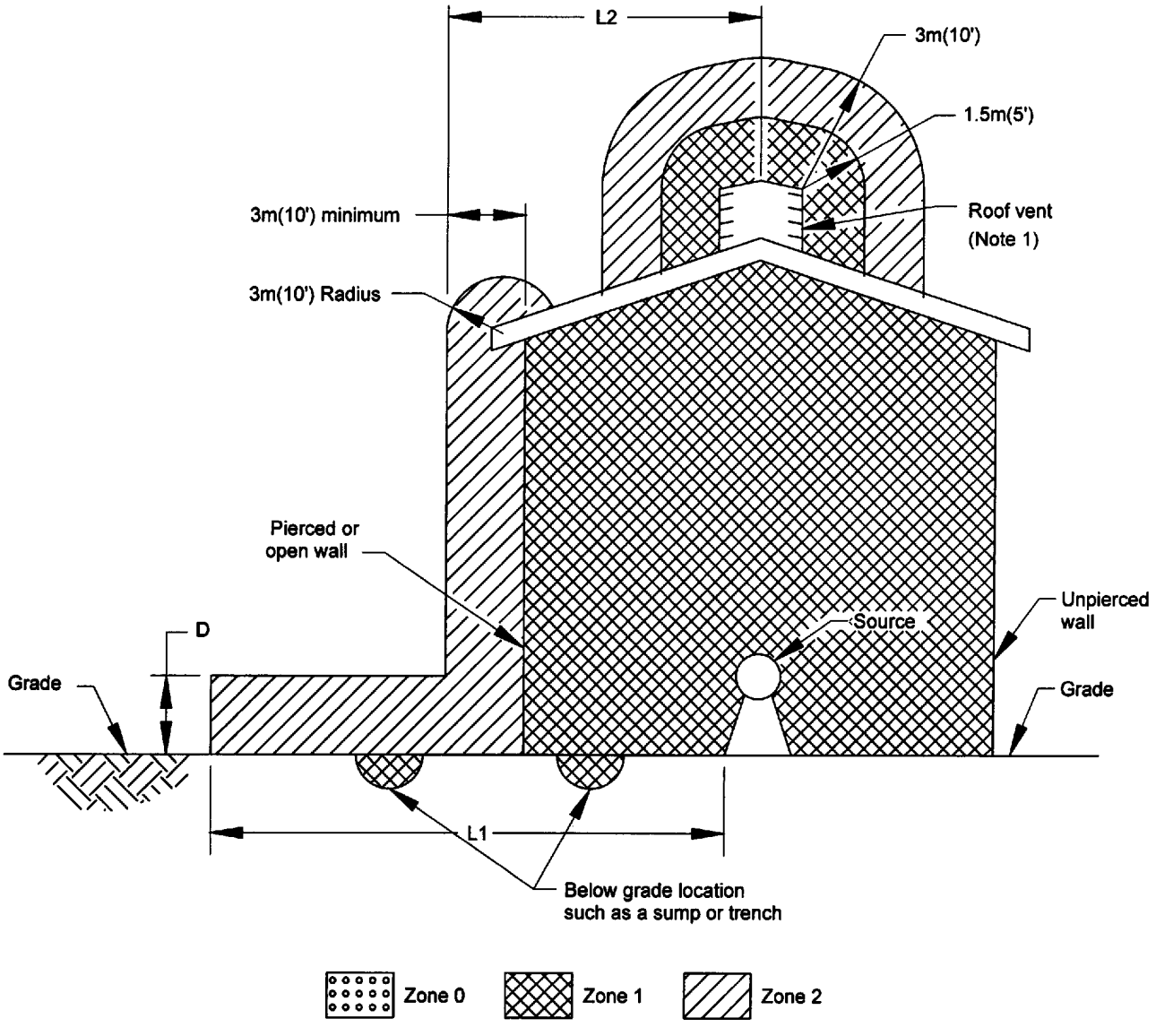


Level	Distance in meters(feet)		
	L1	L2	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	3(10)	.6(2)
2. Liquid above 1900 kPa (275 PSIG) (Note 2)	15(50)	7.5(25)	.6(2)
3. HVL (Note 3)	30(100)	7.5(25)	.6(2)

Notes:

1. The interior of the vent is classified Zone 2. Cross hatching has been omitted for drawing clarity.
2. Level 1 dimensions may be used for small pumps operating above 1900 kPa (275 PSIG) where leakage is likely to be small. Pipeline gathering pumps would normally be included in this exception.
3. Dimension L1 may be reduced to no less than 15 meters (50 feet) where leakage is likely to be small.

Figure 94—Adequately Ventilated Building—Pump or Compressor Handling Flammable Liquids or Highly Volatile Liquids
(See Section 14.3.1.)



Level	Distance in meters(feet)		
	L1	L2	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	3(10)	.6(2)
2. Liquid above 1900 kPa (275 PSIG) (Note 2)	15(50)	7.5(25)	.6(2)
3. HVL (Note 3)	30(100)	7.5(25)	.6(2)

Notes:

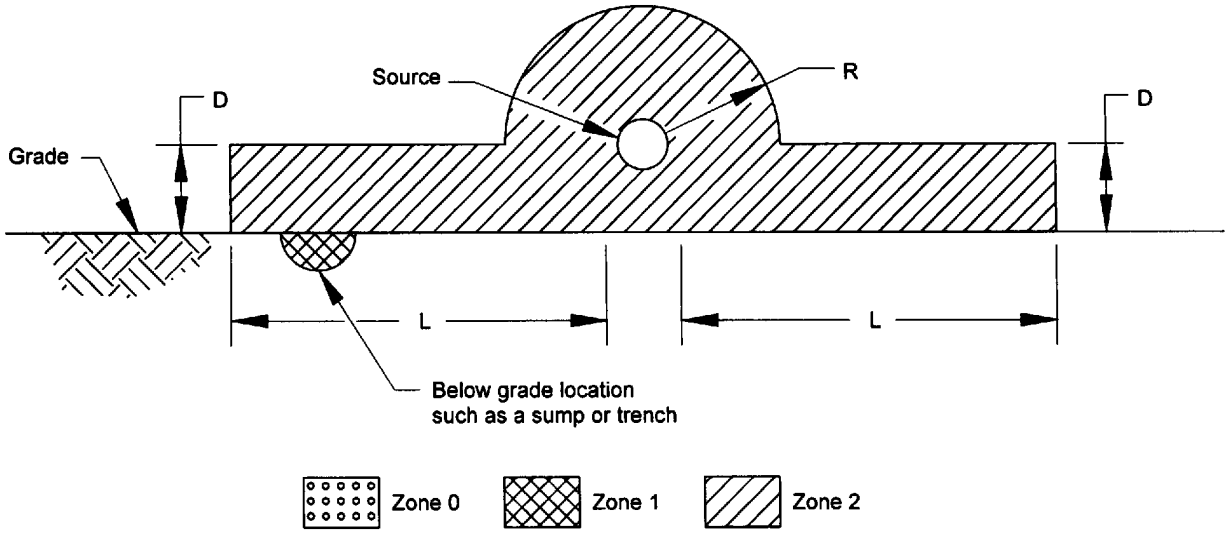
1. The interior of the vent is classified Zone 1. Cross hatching has been omitted for drawing clarity.
2. Level 1 dimensions may be used for small pumps operating above 1900 kPa (275 PSIG) where leakage is likely to be small. Pipeline gathering pumps would normally be included in this exception.
3. Dimension L1 may be reduced to no less than 15 meters (50 feet) where leakage is likely to be small.

Figure 95—Inadequately Ventilated Building Pump or Compressor Handling Flammable Liquids or Highly Volatile Liquids
(See Section 14.3.1.)

14.3.2 Figures 96 through 98 show classified locations around piping with valves, screwed fittings, flanges, or similar accessories handling flammable liquids or highly volatile liquids. They also cover sampling systems, instrumentation and instrument-sized pumps.

14.3.3 Figure 99 shows hazardous (classified) locations around an elevated storage tank or pressure vessel.

14.3.4 Figure 100 shows hazardous (classified) locations around a below grade sump tank or oil-water separator.

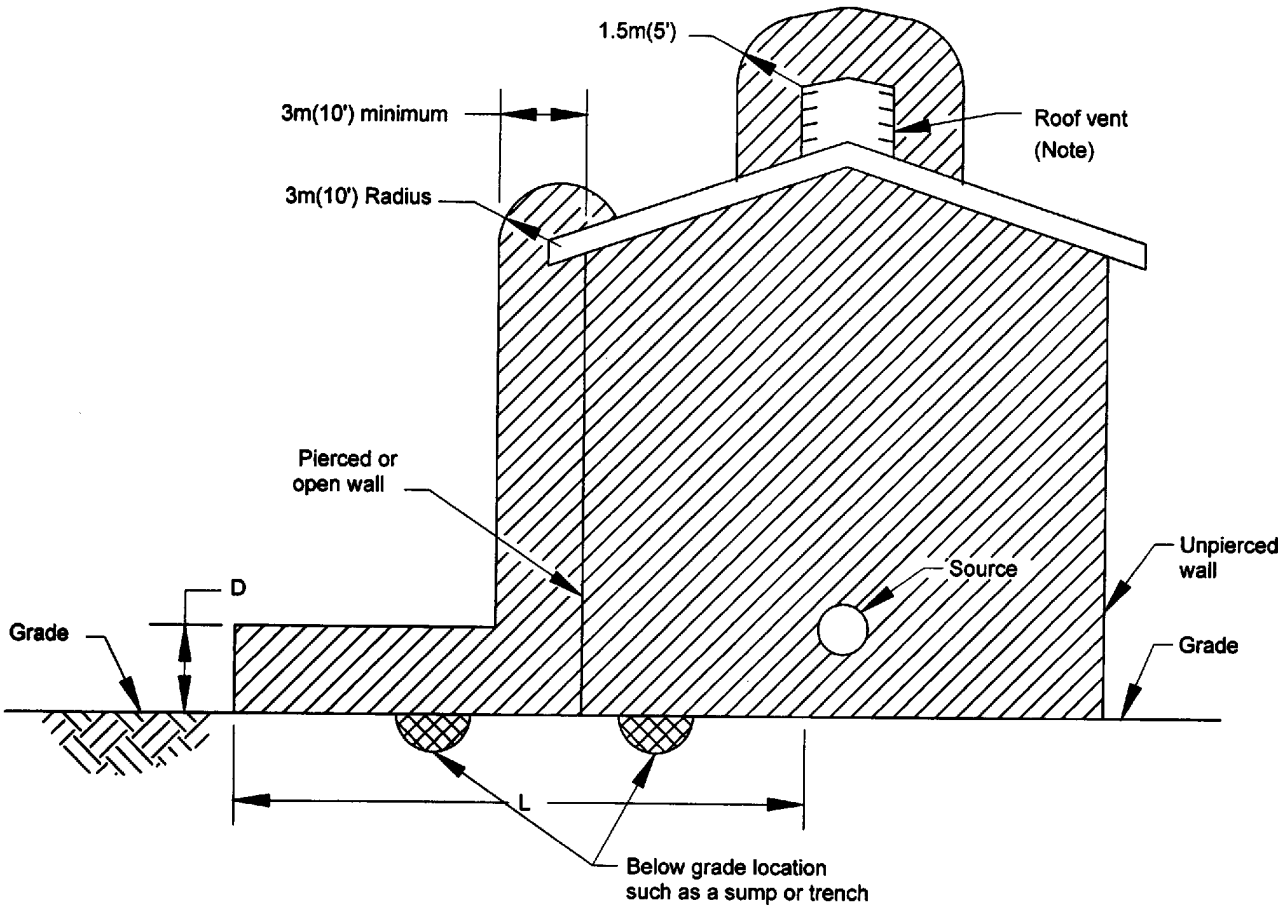


Level	Distance in meters(feet)		
	L	R	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	1(3)	.6(2)
2. Liquid above 1900 kPa (275 PSIG)	3(10)	1(3)	.6(2)
3. HVL	6(20)	3(10)	.6(2)

Note:

Shown for piping installed above grade. Also applies to buried piping with above grade vents, such as motor operated valve body buried and the motor operator above grade.

Figure 96—Outdoors—Piping With Valves, Screwed Fittings, Flanges or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation and Instrument-Sized Pumps (See Section 14.3.2.)

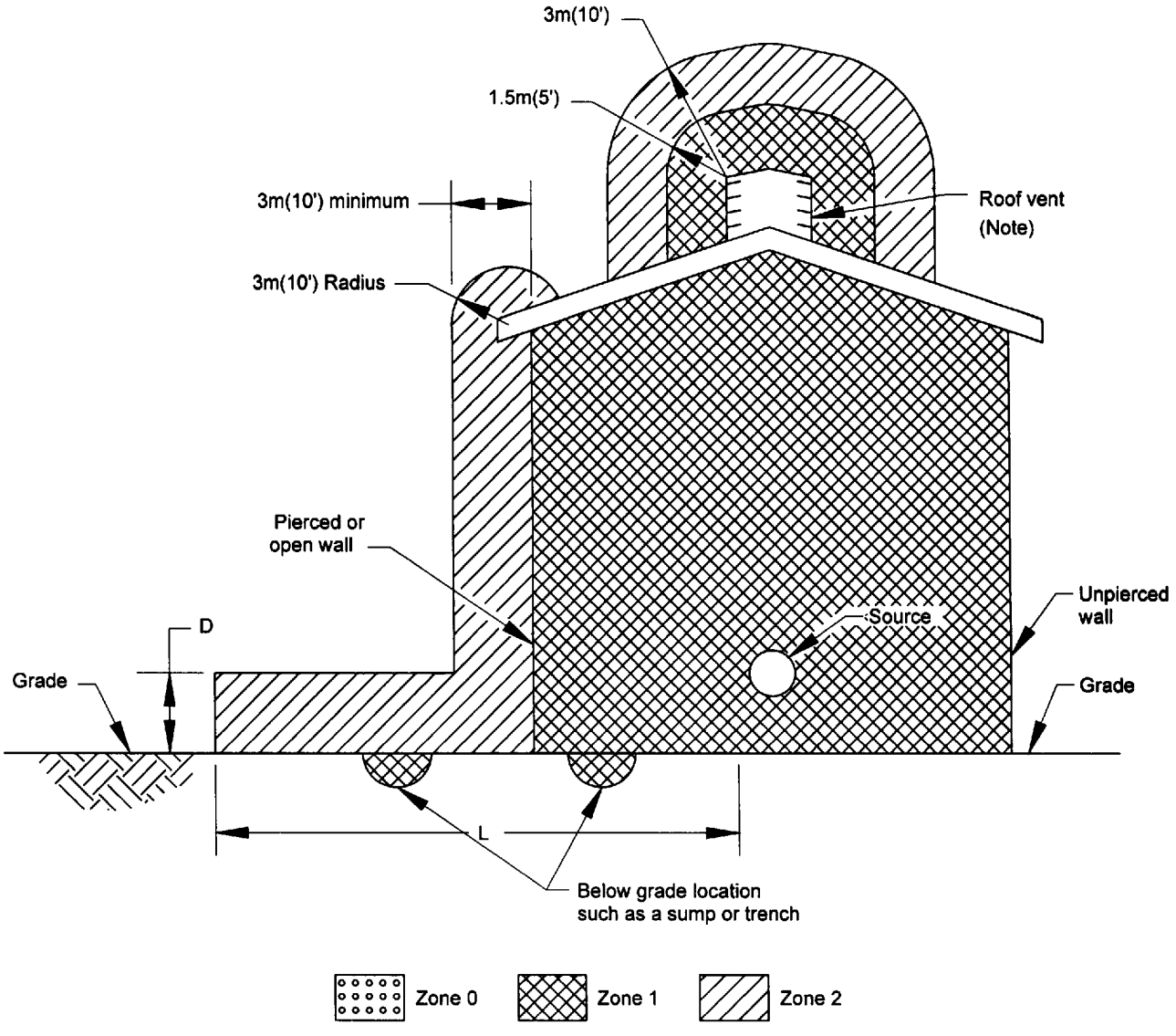


Level	Distance in meters(feet) L	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	.6(2)
2. Liquid above 1900 kPa (275 PSIG)	3(10)	.6(2)
3. HVL	6(20)	.6(2)

Note:

The interior of the vent is classified Zone 2. Cross hatching has been omitted for drawing clarity.

Figure 97—Adequately Ventilated Building—Piping With Valves, Screwed Fittings, Flanges or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation and Instrument-Sized Pumps.
(See Section 14.3.2.)

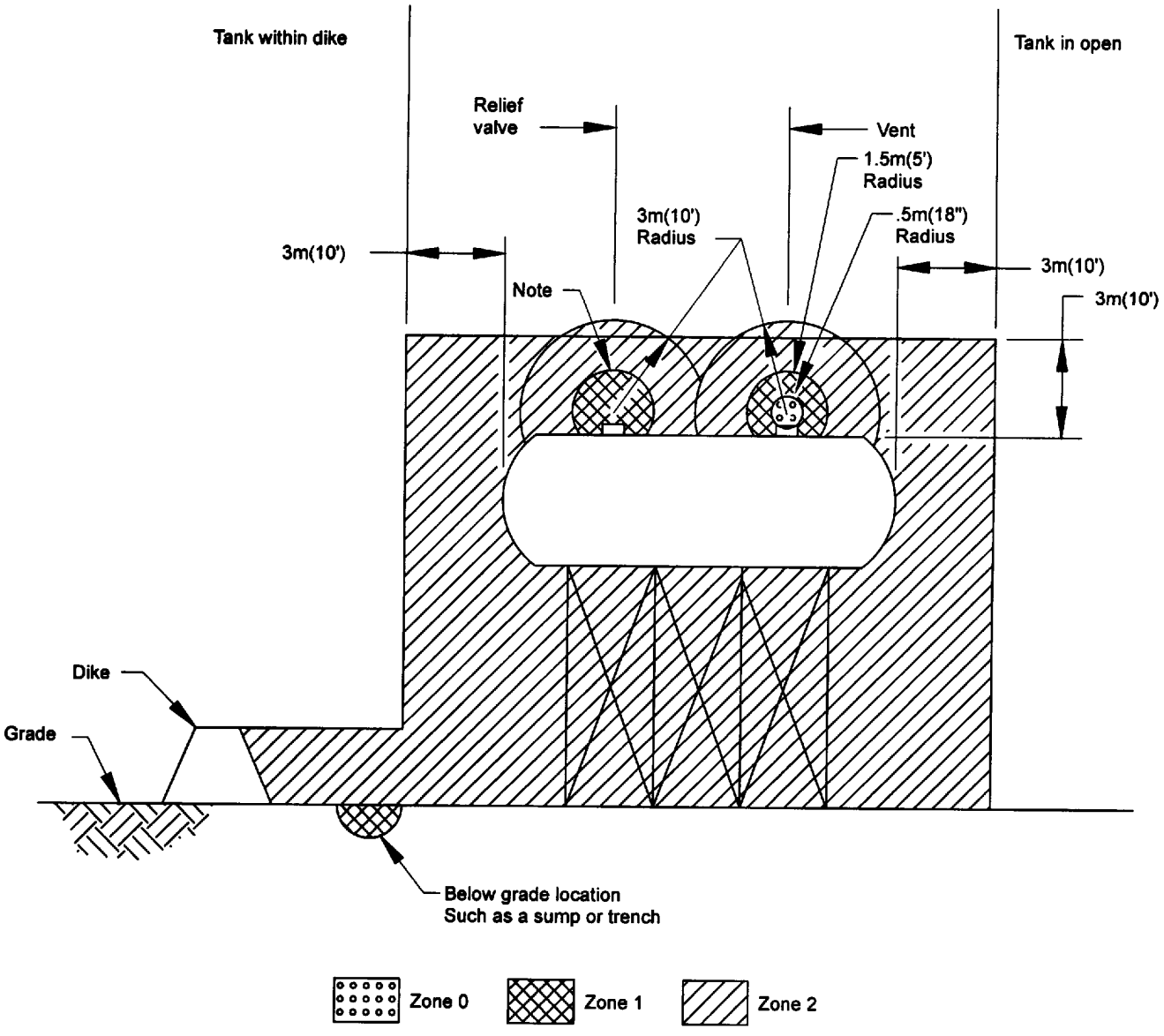


Level	Distance in meters(feet)	
	L	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	.6(2)
2. Liquid above 1900 kPa (275 PSIG)	3(10)	.6(2)
3. HVL	6(20)	.6(2)

Note:

The interior of the vent is classified Zone 1. Cross hatching has been omitted for drawing clarity.

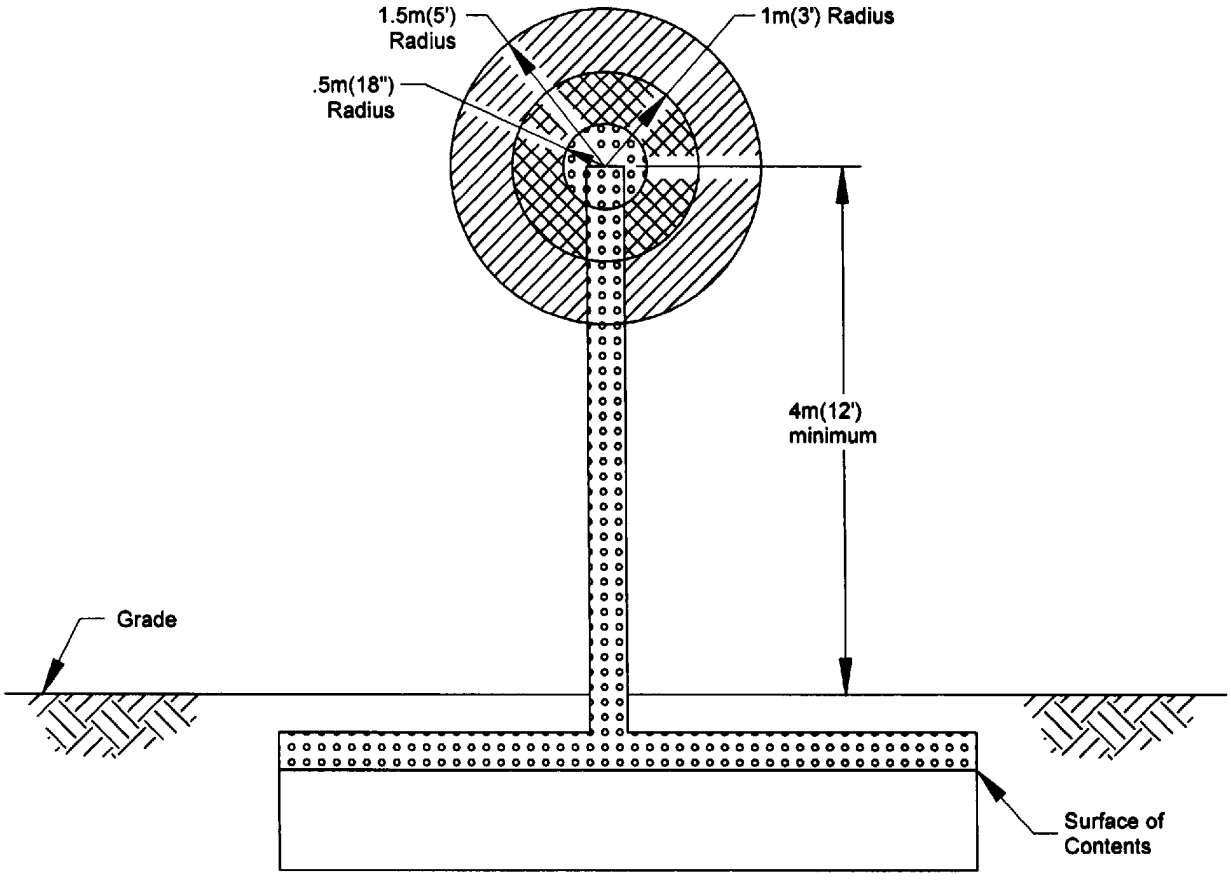
Figure 98—Inadequately Ventilated Building—Piping With Valves, Screwed Fittings, Flanges or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation and Instrument-Sized Pumps.
(See Section 14.3.2.)



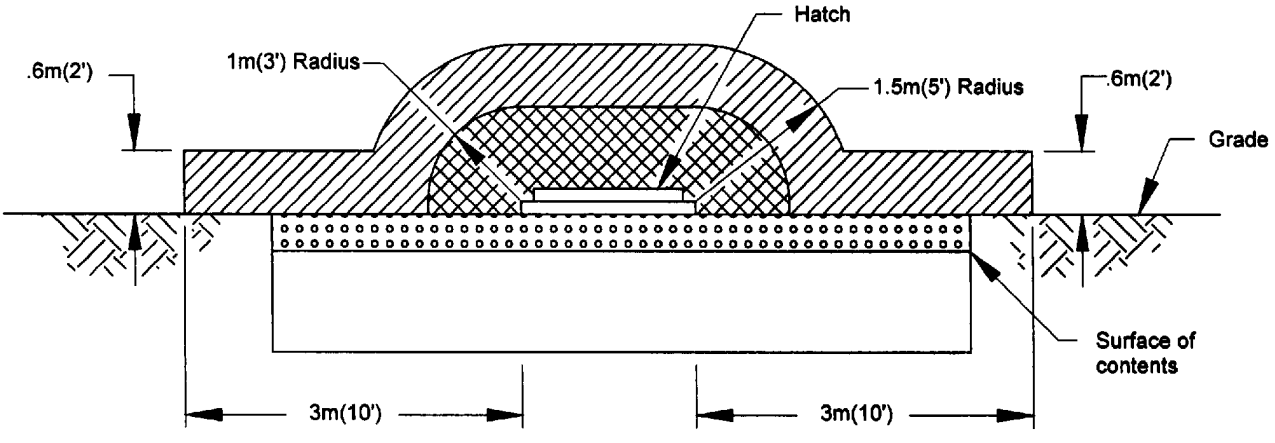
Note:

Refer to: 8.2.3.4 for additional guidance on area classification around relief valves.

Figure 99—Elevated Storage Tank or Pressure Vessel
(See Section 14.3.3.)



A. Below grade with vent

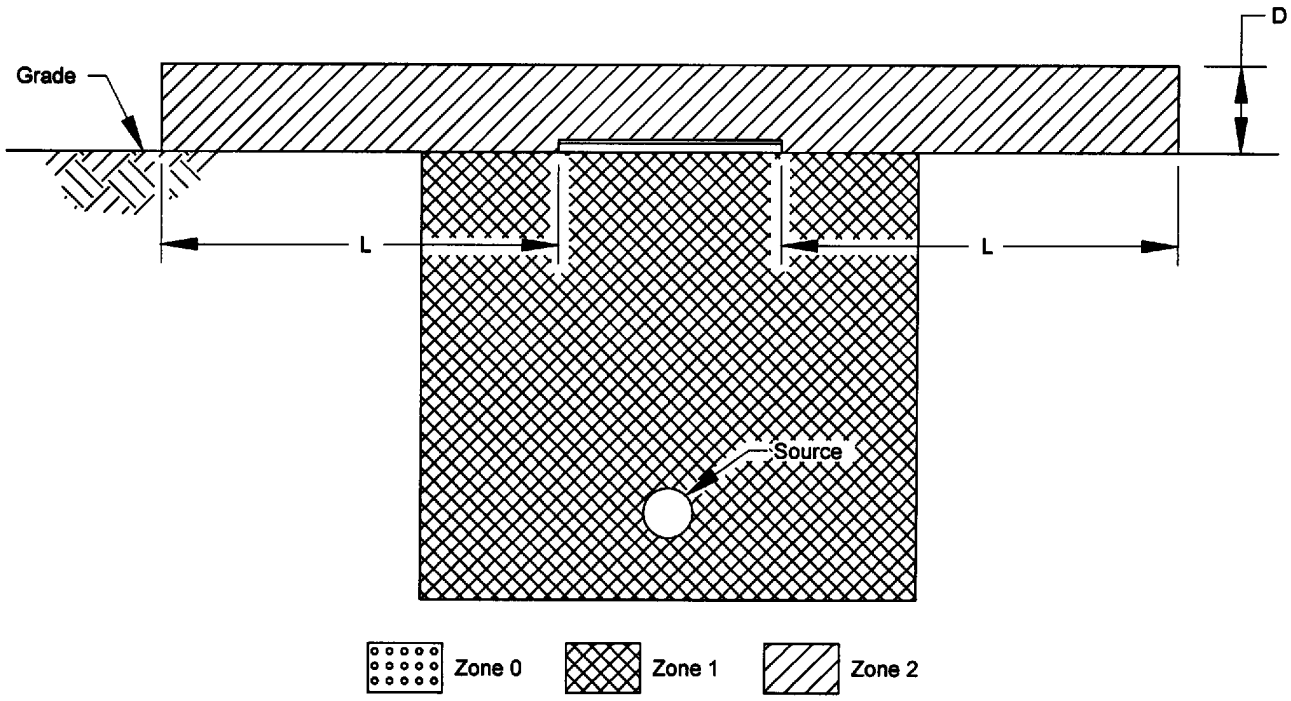


B. Top at grade with access hatch

Figure 100—Below Grade Sump Tank and Oil-water Separator
(See Section 14.3.4.)

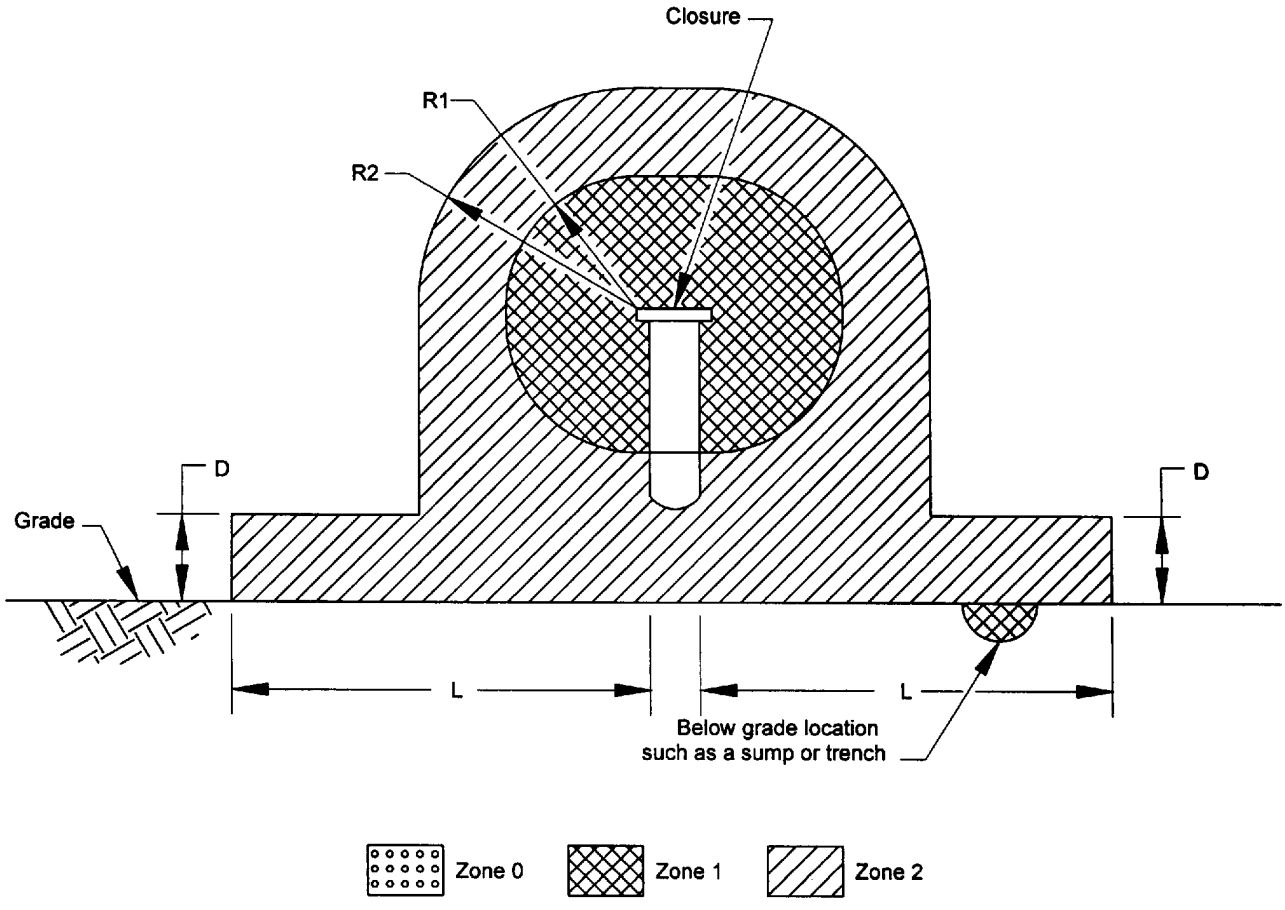
14.3.5 Figure 101 shows hazardous (classified) locations around a below grade vault.

14.3.6 Figure 102 shows hazardous (classified) locations around an above grade source with closure. This figure is applicable to scraper, launchers and receivers, strainers and other devices where the flammable liquid or highly volatile liquid may be exposed to the atmosphere.



Level	Distance in meters(feet)	
	L	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	.6(2)
2. Liquid above 1900 kPa (275 PSIG)	3(10)	.6(2)
3. HVL	6(20)	.6(2)

Figure 101—Below Grade Vault—Piping With Valves, Screwed Fittings, Flanges or Similar Accessories Handling Flammable Liquids or Highly Volatile Liquids. Also Covers Sampling Systems, Instrumentation and Instrument-Sized Pumps.
(See Section 14.3.5.)



Level	Distance in meters(feet)			
	L	R1	R2	D
1. Liquid 1900 kPa (275 PSIG) or less	3(10)	1(3)	1.5(5)	.6(2)
2. Liquid above 1900 kPa (275 PSIG)	3(10)	1(3)	1.5(5)	.6(2)
3. HVL	6(20)	1.5(5)	4.5(15)	.6(2)

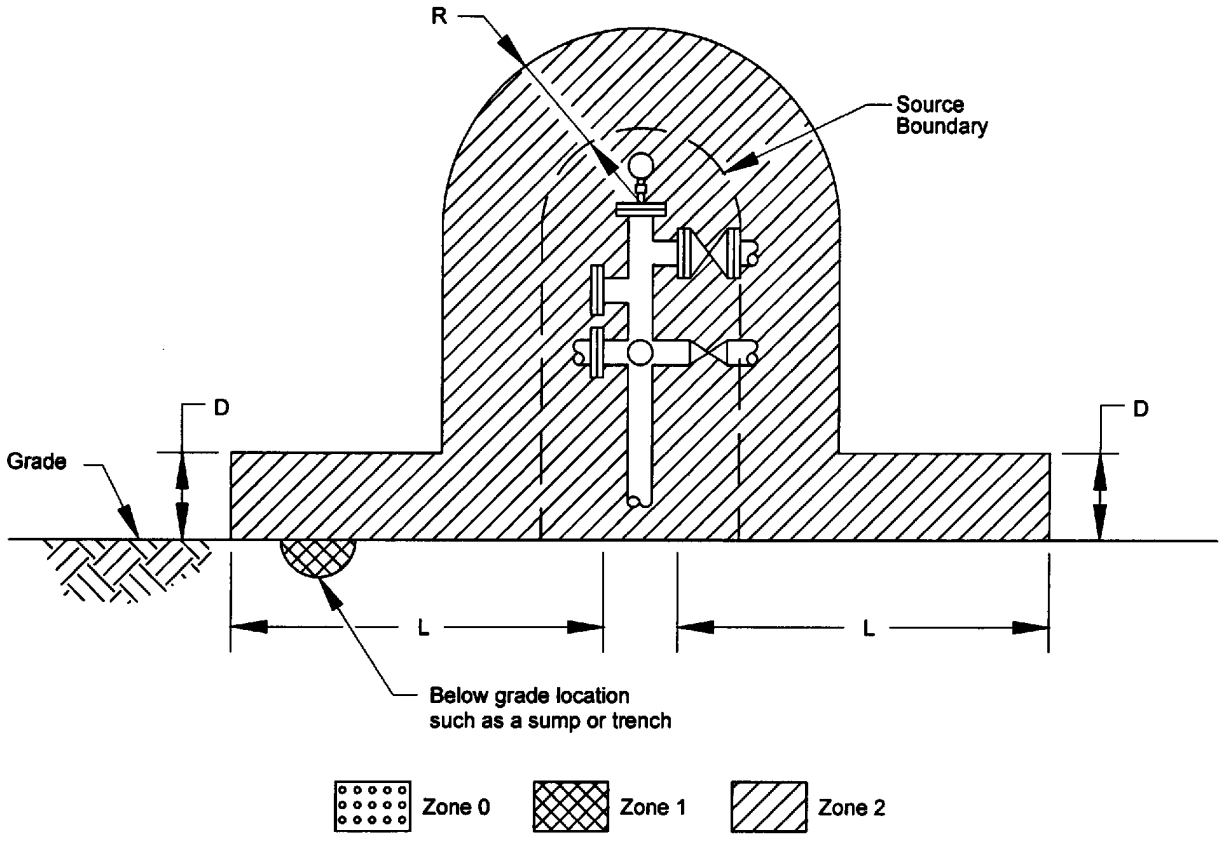
Note:

Applicable to scraper launchers and receivers, strainers and other devices where flammable liquid or highly volatile liquid may be exposed to the atmosphere.

Figure 102—Above Grade Source With Closure
(See Section 14.3.6.)

14.3.7 Figure 103 shows hazardous (classified) locations around a storage cavern.

14.3.8 Figures 104 through 106 show hazardous (classified) locations around a compressor, or other source handling lighter-than-air flammable gases.

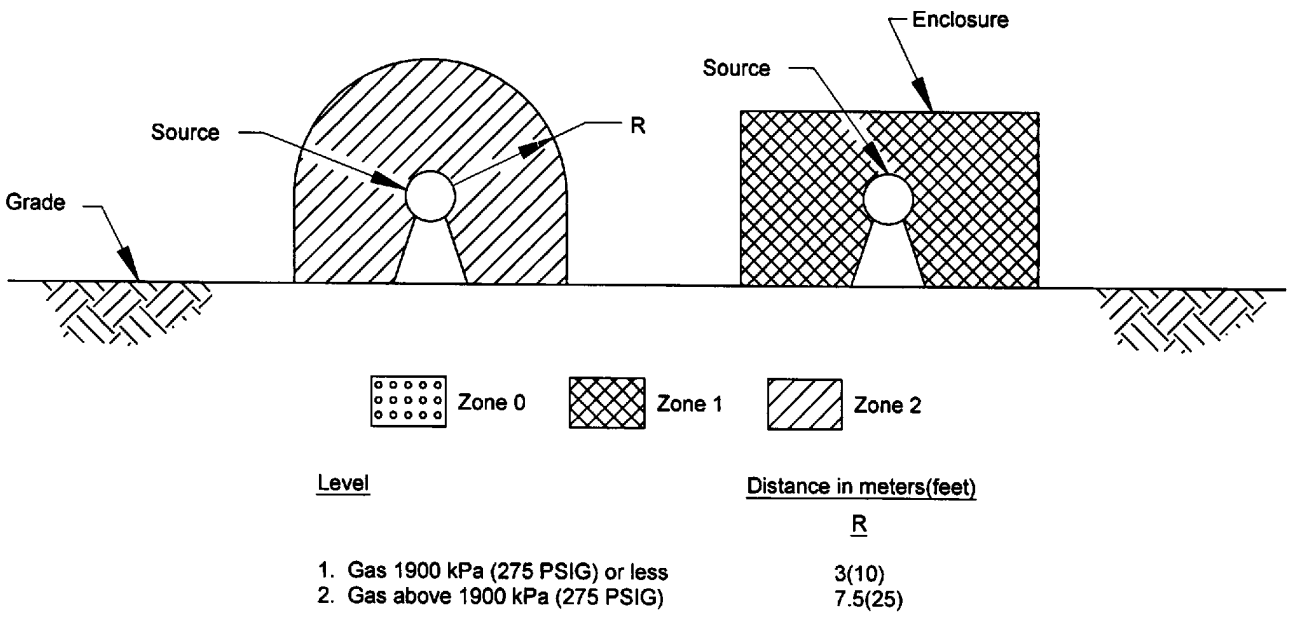


Level	Distance		
	L	R	D
1. Liquid 1900 kPa (275 PSIG) or less	6(20)	3(10)	.6(2)
2. Liquid above 1900 kPa (275 PSIG)	6(20)	3(10)	.6(2)
3. HVL	15(50)	7.5(25)	.6(2)

Note:

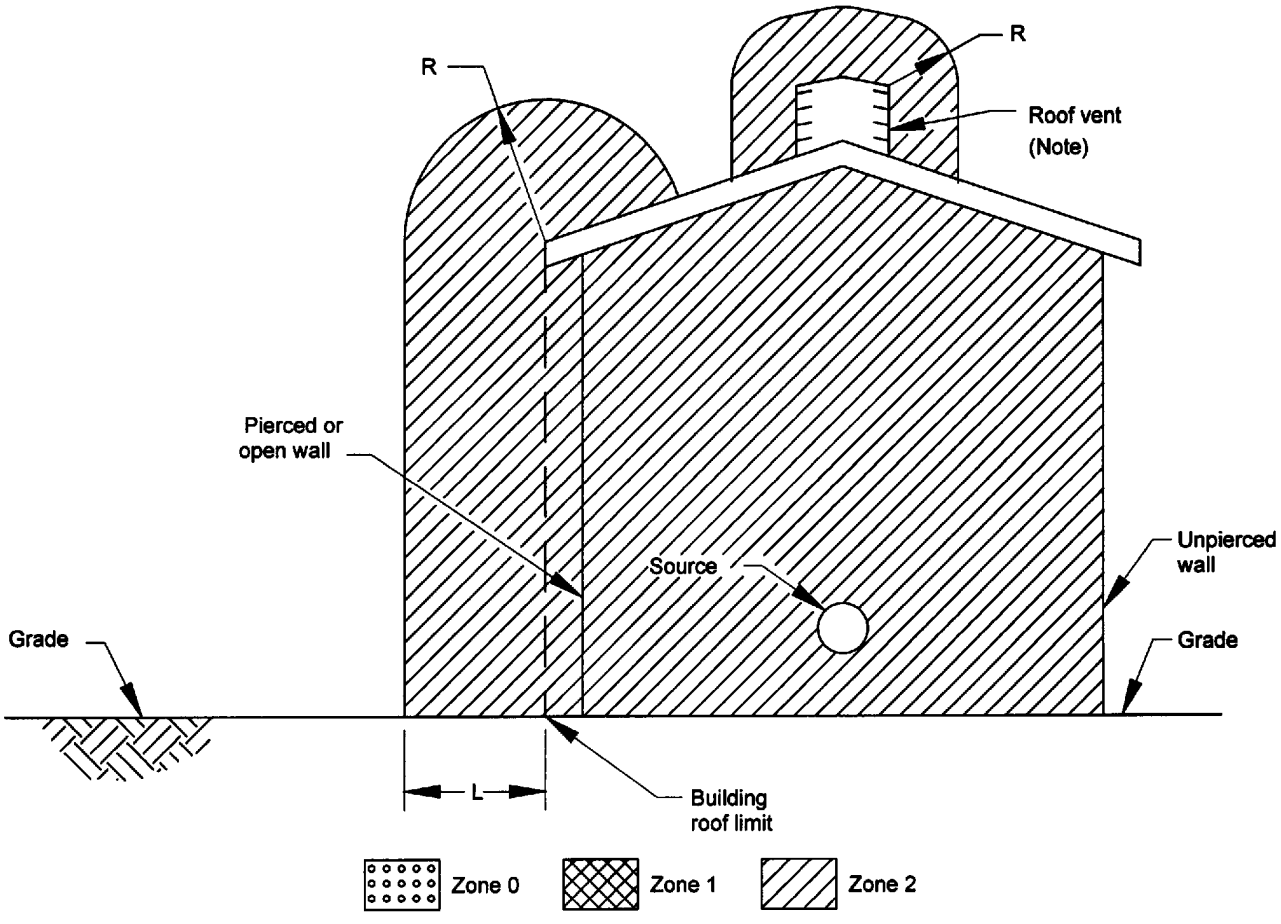
Displacement medium should be treated as flammable liquid because of the entrained ingredients.

Figure 103—Storage Cavern
(See Section 14.3.7.)



Level	Distance in meters(feet) R
1. Gas 1900 kPa (275 PSIG) or less	3(10)
2. Gas above 1900 kPa (275 PSIG)	7.5(25)

Figure 104—Outdoors—Compressor or Other Source Handling Lighter-Than-Air Flammable Gas (See Section 14.3.8.)

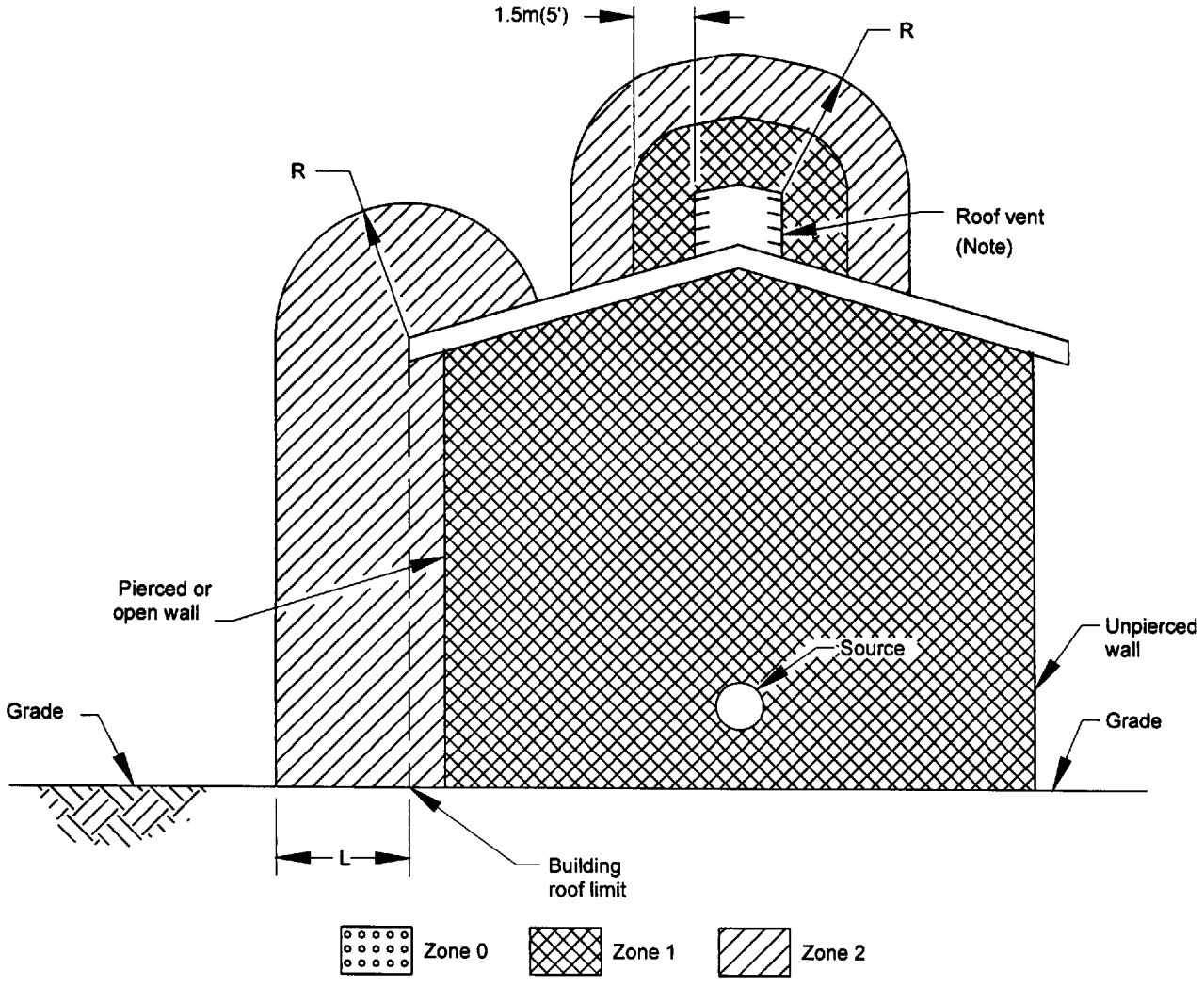


Level	Distance in meters(feet)	
	L	R
1. Gas 1900 kPa (275 PSIG) or less	3(10)	3(10)
2. Gas above 1900 kPa (275 PSIG)	7.5(25)	7.5(25)

Note:

The interior of the vent is classified Zone 2. Cross hatching has been omitted for drawing clarity.

Figure 105—Adequately Ventilated Building—Compressor or Other Source Handling Lighter-Than-Air Flammable Gas
(See Section 14.3.8.)



Level	Distance in meters(feet)	
	L	R
1. Gas 1900 kPa (275 PSIG) or less	3(10)	3(10)
2. Gas above 1900 kPa (275 PSIG)	7.5(25)	7.5(25)

Note:

The interior of the vent is classified Zone 1. Cross hatching has been omitted for drawing clarity.

Figure 106—Inadequately Ventilated Building—Compressor or Other Source Handling Lighter-Than-Air Flammable Gas
(See Section 14.3.8.)

APPENDIX A—SAMPLE CALCULATION TO ACHIEVE ADEQUATE VENTILATION OF AN ENCLOSED AREA BY NATURAL MEANS USING EQUATIONS 1 AND 2

The inside dimensions of a building are given as 6' 0" wide x 8' 0" long x 7' 6" high.

V = width x length x height
V = 6' x 8' x 7.5' = 360 ft^3

Assume values of T_i and T_o as follows:
T_i = 80°F = 540°R
T_o = 70°F = 530°R

The vertical center-to-center distance (H) between A_1 and A_2 is 6 feet, and $A_1 = A_2$.

Using Equation 2:

$$h = \frac{H}{1 + [(A_1/A_2)^2 T_i/T_o]} \qquad \text{A2}$$

$$h = \frac{6}{1 + 540/530}$$

$$h = 2.97\,ft$$

Using Equation 1:

$$A = \frac{V}{1200\sqrt{h(T_i - T_o)/T_i}}$$

$$A = \frac{360}{1200\sqrt{2.97(10)/540}}$$

$$A = 1.28\,ft^2$$

$$A = 1.28\,ft^2(184.2\,in^2)$$
for both inlet and outlet

A.1 Number of Louver Panels Required:

$$\frac{184.2\ \text{in}^2}{200\ \text{in}^2/\text{louver panel}} = .92 \text{ louver panel required for both inlet and outlet.}$$

A.2 Required Ventilation:

Required ventilation can be provided by one louver panel of 200 square inches each for inlet and outlet, for a total of 400 square inches of ventilation area.

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APPENDIX B—CALCULATION OF MINIMUM AIR INTRODUCTION RATE TO ACHIEVE ADEQUATE VENTILATION USING FUGITIVE EMISSIONS

General. An alternative method of providing adequate ventilation for an enclosed area is to make a reasonable estimate of fugitive emissions from hydrocarbon-handling equipment within the enclosed area and provide sufficient diluent ventilation. This method was adopted by NFPA 30 (1990). Application of this method requires certain calculations, and one technique is described below. In calculating the ventilation rate required, the hydrocarbon leakage rate anticipated (under normal operations) must be determined. Then, sufficient dilution air must be added to the space in question to ensure that the concentration of flammable vapor or gas is maintained below 25 percent of the lower flammable limit (LFL) for all but periods of process upset, abnormal equipment operation, rupture, or breakdown.

Anticipated fugitive emission factors for specific hydrocarbon handling equipment can be obtained from existing publications. Existing publications include API Publication 4322 "Fugitive Hydrocarbon Emissions from Petroleum Production Operations." Volume I and II, 1980, an EPA/ Radian Study conducted in 1979, and EPA's "Protocols For Generating Unit-Specific Emission Estimates for Equipment Leaks of VOC and HAP," 1987 (Document No. 87-222-124-10-02). Additional data can be found in API Publication 4589 "Fugitive Hydrocarbon Emissions from Oil and Gas Operations," 1993, and API Publication 4615, "Emission Factors for Oil and Gas Production Operations," 1995. All emission data used should be reviewed to assure emission rates are representative of actual conditions during normal operations.

Recommended Calculation Technique. In the example below, the required ventilation rate will be determined for an enclosed area (60'W x 120'L x 40'H) on an offshore platform containing production equipment.

1. Select the appropriate table (i.e., offshore, onshore, or gas plant) in Section E of API Publication 4322, Fugitive Hydrocarbon Emissions from Petroleum Production Operations, to determine the total anticipated fugitive emissions. For the specific case given above, Table E-2 for offshore production operations is applicable.
2. Utilize Table D-4 to list the total applicable hydrocarbon-handling components, and their anticipated total hydrocarbon fugitive emissions. It is recommended that these components be listed in a table.
3. The total number of specific components handling hydrocarbons should be obtained by an actual field count for existing equipment or from the design drawings for proposed equipment. Note that components handling gas should be listed separately from those handling other hydrocarbons (primarily crude oil or condensate).
4. In the table prepared in Step 3 above, list the total hydrocarbon prediction factors corresponding to the listed components handling gas.
5. Determine the total anticipated gas emission (pounds/day) for each component by multiplying the number of components by the applicable prediction factor. This product is the total gas emission anticipated for that specific type component.
6. Subtotal the total anticipated gas emissions (pounds/day) for all components to obtain the total gas service emission rate.
7. Repeat Steps 4 through 6 to determine the "Other Service" total anticipated emissions. "Other Service" includes hydrocarbon liquids.
8. Add the subtotals from Steps 6 and 7 to determine the total anticipated hydrocarbon emissions for the area.
9. Convert the total hydrocarbon emissions from pounds/day to pounds/hour. For the example chosen, assume that the total anticipated hydrocarbon emissions is 297.26 lb/day. Dividing by 24, the conversion yields 12.39 lb/hour.
10. Calculate the average mole weight of the hydrocarbon emissions. An example follows:

83%	methane (Molecular Weight = 16)	0.83 x 16 = 13.28
13%	ethane (Molecular Weight = 30)	0.13 x 30 = 3.90
4%	butane (Molecular Weight = 58)	0.04 x 58 = 2.32
100%		Total = 19.50

To simply further calculations, the 19.5 is rounded to 20, and 20 is used as the average mole weight of the hydrocarbon emissions mixture.

11. Calculate the cubic feet/pound-mole at the estimated ambient temperature of the area. This calculation is made utilizing the fact that the volume of one pound-mole of an ideal gas is 359 cubic feet at standard temperature and pressure (32°F and 14.7 psia).

From the Gas Law (PV = nRT) and Charles' Gas Law ($V_1 T_2 = V_2 T_1$), gas volume at constant pressure varies proportionately to the ratio of temperatures when the temperature is expressed in degrees Rankine (°F + 460).

Assuming an ambient temperature of 88°F, an example follows:

At 88°F and 14.7 psia, 359 cubic feet of ideal gas would occupy:

(359) (460 + 88)/(460 + 32), or 400 cubic feet

12. Determine the total hydrocarbon leak rate in cubic feet per minute (cfm) using the equation:

$$G = \frac{(E)(V)}{60(mw)} \qquad \text{A3}$$

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Where:

G = Leak rate, cfm
E = Emission rate, lb/hour
V = Volume, ft³/l b-mole
mw = Average mole weight
60 = minutes/hour

As an example, if E = 12.39 lb/hr and the average mole weight is 20,

G = (12.39 lb / hr) (400 ft³ / lb-mole)/(60 min/hr) (20)
G = 4.13 cfm

13. As per NFPA 69, Explosion Prevention System, the hydrocarbon concentration may be expressed by the following equation:

$C = (G/Q)(1-e^{-kn})$,

Where:

C = Concentration of hydrocarbon in air, percent (expressed in decimal format)
G = Leak rate, cfm
Q = Fresh air introduction rate, cfm
n = Number of air changes

It follows that $Q = G/C$ after steady state conditions, as the term $(1-e^{-kn})$ approaches one (1).

As an example, if the leakage rate is assumed to be 4.13 cfm, 100 percent LFL methane is assumed (.05 concentration), and it is desired to maintain a 25 percent LFL mixture, the required fresh air introduction rate may be determined as follows:

Q = 4.13 cfm / (0.25 x 0.05)
Q = 330 cfm

14. Using a safety factor of four (4), the required ventilation rate is determined as follows:

Q = 330 cfm x 4
Q = 1320 cfm, the minimum ventilation rate

Thus, minimum ventilation to achieve adequate ventilation for an enclosed area of the size given, above which contains the fugitive emission sources assumed, is 1320 cfm.

Note 1: Depending on the size of the enclosed area and the equipment configuration, supplemental internal recirculation may be advisable to avoid inversion layers or stagnant areas

Note 2: The above procedure is adapted from *Module Ventilation Rates Quantified*, Oil and Gas Journal, W. E. Gale, December 23, 1985, p. 41.

APPENDIX C—PREFERRED SYMBOLS FOR DENOTING CLASS I, ZONE 0, ZONE 1, AND ZONE 2 HAZARDOUS (CLASSIFIED) AREAS (IEC 79-10, MOD)

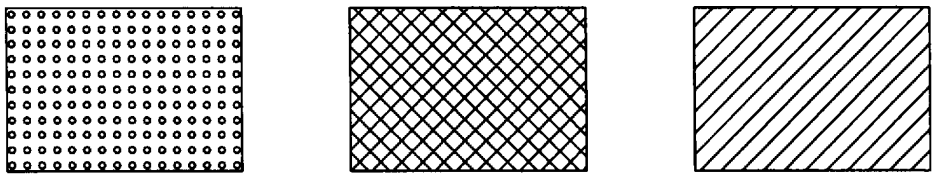

Figure C-1—Preferred Symbols for Denoting Class I, Hazardous (Classified) Zones

APPENDIX D—INFORMATIVE ANNEX—AN ALTERNATE METHOD FOR AREA CLASSIFICATION

D.1 Introduction

D.1.1 This section presents an alternate method for classifying adequately ventilated locations in non-enclosed locations for electrical installations at petroleum facilities.

D.2 Explanation of "Point Source" Concept

D.2.1 Developing area classification boundaries using the concept of "Point Source" involves creating the classified area boundaries for all individual potential sources and then superimposing all of the boundaries created by the individual point sources to develop a composite classified area boundary for all sources combined. Usually the composite boundary will be simplified and extended beyond that defined by each individual point.

14.3.9 The recommendations presented below provide a means to evaluate the extent of classified areas in non-enclosed adequately ventilated locations based on the nature of potential flammable releases. These means are being introduced to recognize that as the quantity of potential sources is reduced, the extent of classified areas tends also to be reduced. Also, other factors such as the volatility of the released materials, the quantity of the release, weather, nature of the release, and the velocity of the material released can have an influence on the boundaries of classified areas. This alternative method will present area classification schemes that consider volatility and release rates.

D.2.2 The concept of "Hazard Radius" is being introduced. The concept of hazard radius is a function of two parameters: the volatility of the material being released and the rate of release of the material. For less volatile materials with low release rates, the hazard radius is quite small. For more volatile materials with a low release rate, or for less volatile materials with a high release rate, the hazard radius will be "midrange". For a highly volatile material released at a high rate, the hazard radius will be large. The velocity of the release will have a significant influence on the hazard radius. High velocity releases, normally considered as releases over 50 ft/sec, will often result in misting of the material. Misting, coupled with moderate winds, can result in relatively large hazard radii. In a similar manner, low velocity releases, normally considered as releases less than 10 ft/sec, will not normally be influenced by weather conditions, and the hazard radius may be relatively small. As an example, gasoline released through a fine nozzle at a rate of 5 gallons per minute in a 3 mph wind would result in rather large vapor cloud. However, gasoline poured slowly from a container at a rate of 5 gallons per minute would have a very limited vapor cloud, somewhat independent of the wind velocity. Misting, vapor release rates, velocities of, vapor releases, and volatility are all important factors to consider when developing area classification boundaries.

D.3 Determination of Volatility Classification

D.3.1 The flammability of various liquids, vapors, and gases is well documented (e.g., NFPA 30 Flammable and Combustible Liquids Code). The volatility of a material can have a significant impact on area classification Figure D-1 is a chart used to determine the relative volatility of a material based on fluid process temperature and fluid vapor pressure. The basic concept for this approach is derived from the Institute of Petroleum publication IP-15, Area Classification Code for Petroleum Installations, Appendix B. The data relating to the flammability of specific materials is based primarily on various NFPA documents.

D.3.2 This process groups all flammable liquids, vapors, and gases into one of five "Volatility Categories":

Category G materials include flammable fluids handled or processed as gases or vapors.

Category 1 materials include LPGs and light hydrocarbons (butane and lighter) and heavier flammable and combustible liquids with a vapor pressure above 70 psia at operating temperature. These materials, when released, will almost completely vaporize in a very short period of time. Category 1 materials will almost immediately flash to a vapor, even when they are processed in a liquid form. For example, when liquid propane is released, it will immediately flash to a vapor. At 90°F and 150 psi, one-third of propane will flash immediately and cool the liquid to -44°F, and the liquid will continue to boil and vaporize as it absorbs heat from the ground. A second example would be hot kerosene. Normally, kerosene at room temperature and low pressures would be considered an unclassified material However, when kerosene is operated at 500°F, the vapor pressure will be over 70 psia, and this hot material would be considered a Category 1 material. When it is released to the atmosphere, about 45% would flash to a vapor, cooling the liquid to about 410°F. The remaining liquid will "pool" and continue to evaporate at a reduced rate until it cools to ambient. Even an asphaltic type material, when processed at very high temperatures, will exhibit similar characteristics when initially released.

Category 2 materials are all Class 1A Flammable Liquids that are operated at temperatures producing a vapor pressure of 70 psia or less and all other flammable and combustible liquids with a vapor pressure between 14.7 psia and 70 psia at operating temperature. Pentane is an example of a Class 1A

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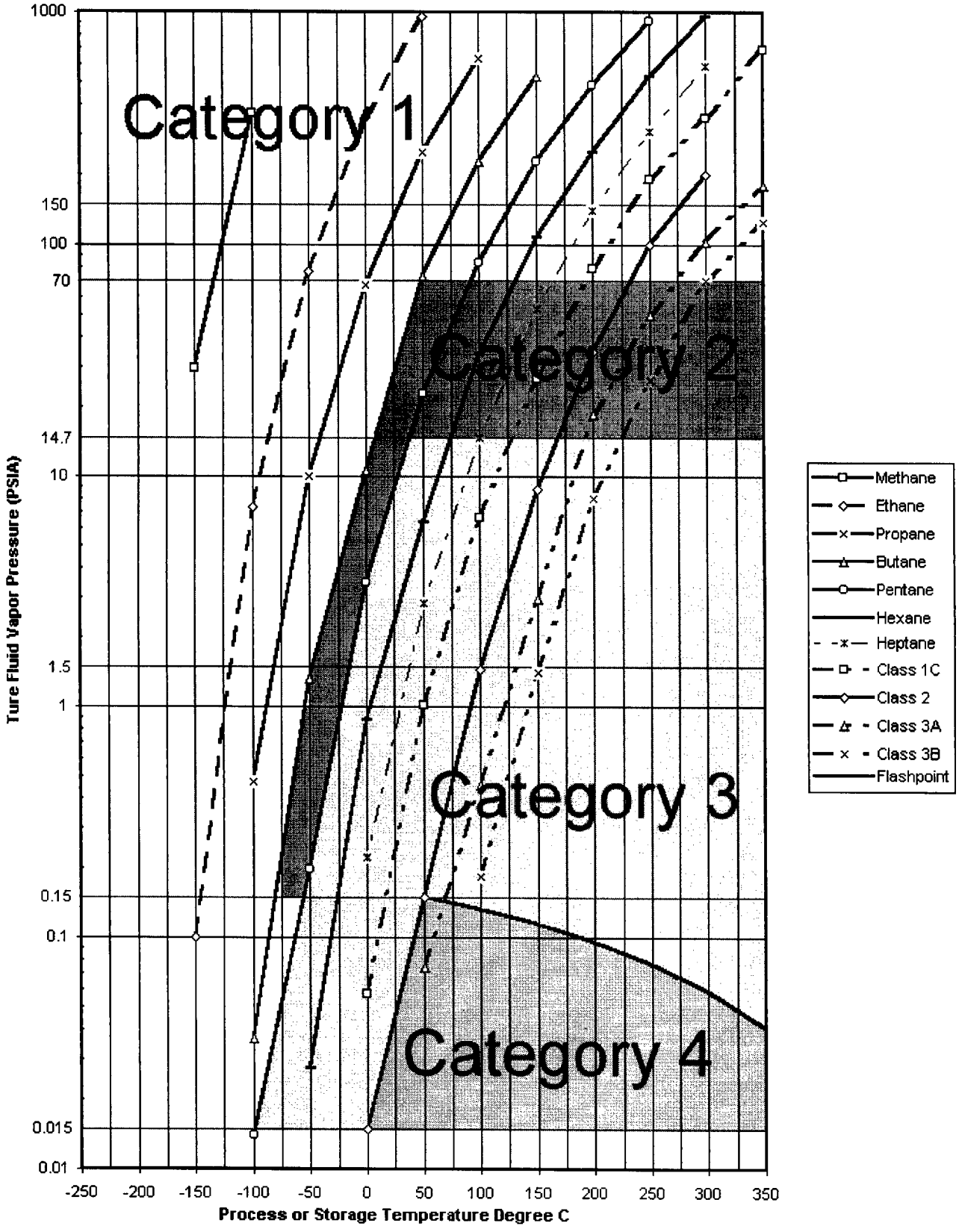


Figure D-1—Vapor Pressure—Temperature Volatility Chart

Flammable Liquid. It would be considered a Category 2 material for all operating temperatures in which the vapor pressure is less than 70 psia (195°F and lower). If Category 2 pentane at 140°F should be released to the atmosphere approximately 1/6 would immediately vaporize, and the liquid would pool, and eventually all the pentane would evaporate. Isopropyl alcohol would be a Category 3 material at room temperature, but would be a Category 2 material when operated above its boiling point of 180°F. It would be a Category 1 material when operated above 265°F. As a Category 2 material at 260°F, when released to the atmosphere it would act similar to the pentane example above—i.e., about 1/4 will initially flash, and the remainder will have a high evaporation rate.

Category 3 materials are all Class 1 B Flammable Liquids that are operated at temperatures producing a vapor pressure less than 14.7 psia, and also all other flammable and combustible liquids that are operated at temperatures producing a vapor pressure less than 14.7 psia when the process or storage temperature is above the flash point of the material. An example would be kerosene at 150°F. A leak of this material would flash very little vapor, and the resulting pool would have a moderate evaporation rate.

Category 4 materials are all Class II and heavier materials that are operated below their flash point. Examples of Category 4 materials would be kerosene, lubrication oil, asphalt, and diesel fuel handled at room temperature. These materials will not produce a flammable fuel-air mixture when released at operating conditions. When operated at elevated temperatures, most of these materials are in a higher hazard category.

Note: The following standards provide additional information on the properties of flammable and combustible liquids, gases, and volatile solids:

NFPA[14]

NFPA 30	*Flammable and Combustible Liquids Code*
NFPA 325	*Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids*
NFPA 497	*Recommended Practice for Classification of Class I Hazardous (Classified) Locations For Electrical Installations In Chemical Process Areas*

D.4 Determination of the Hazard Radius for Area Classification Purposes

If one knows either (a) the operating or storage temperature of a specific material, or (b) both the temperature and vapor pressure of any flammable or combustible material, they can determine whether the material is a Category 1, 2, 3, or 4 material. For materials in Categories 1, 2, 3, and 4, the extent of the classified area, or "hazard radius", will be a function of the material release rate and the dispersion rate of the gases and vapors. Section D.5 addresses heavier-than-air sources located in non-enclosed, adequately ventilated locations. Section D.6 addresses lighter-than-air sources located in non-enclosed, adequately ventilated areas.

D.5 Application to Non-Enclosed, Adequately Ventilated Locations Containing a Heavier-Than-Air Gas or Vapor Source

D.5.1 General

The matrix in Figure D-2 provides a means for determining a hazard radius as a function of the volatility category and the release rate. Using the matrix, a Category 3 fluid with a release rate of less than 10 gpm would result in a hazard radius of 3 feet. A Category 1 fluid with a release rate of between 50 and 100 gpm would result in a hazard radius of 50 to 100 feet. One should recognize that both the volatility categories and the product release rates are actually a continuum rather than absolute, and one should use good engineering judgment in determining hazard radius. This method should not be used for classifying locations when the anticipated release rate from a source exceeds 100 gpm. The hazard radii presented are based on sources with some misting or impingement. As the level of misting increases one should expect that the hazard radius would also increase. Conversely, sources with extremely low release velocities could have appreciably smaller hazard radii. The nature or configuration of the source of the release can have a significant impact on the hazard radius.

With knowledge of the volatility category and the source release rate, one can enter the matrix in Figure D-2 and determine a hazard radius. This hazard radius should be used in conjunction with the recommendations below for determining the extend of classified areas.

It often is quite difficult to determine the hazard radius for streams that contain a mixture of different components of which some are volatile hydrocarbons. The reason for this is twofold. First, during a release it is sometimes difficult to know the extent of dispersion for a hydrocarbon mixture. Second, the majority of technical data pertaining to area classification groups only addresses pure components and does not address mixtures. (See Section 5.5.4, which addresses hydrogen sulfide and methane mixtures). The first concern can be addressed to some extent using commercially available dispersion modeling programs. Using these programs, one can achieve indications of the Lower Flammable Limit (LFL) and 50% LFL for gas mixtures. It should be noted that dispersion modeling often requires special skills and knowledge for one to apply the techniques. Beyond the guidance provided in Section 5.5., testing is currently the only reliable method for determining the group for gas mixtures. The hazard radius matrix shown in Figure D-2 can be applied to mixtures to determine the extent of the classified location. In the case of mixtures, one would first determine the mass release

[14]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

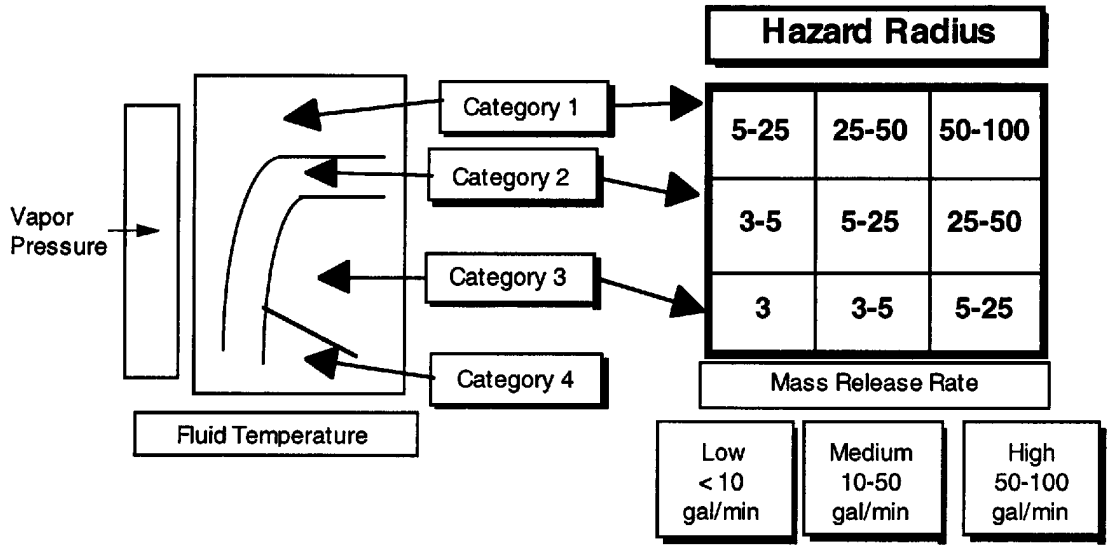


Figure D-2—Volatility—Release Rate Matrix for Determining Hazard Radius

rate for the volatile portion of the mixture. Assuming that all of the volatile hydrocarbons are freely dissipated from the mixture during the release, one can then determine both the category and rate of release for that portion and determine a hazard radius. This method will result in a conservative hazard radius.

The following sections provide two methods for determining the boundaries of classified locations. The reader is reminded that the method is valid only for non-enclosed, adequately ventilated locations.

D.5.2 Point Source Located Near or Above Grade—Adequately Ventilated Location

The first method, using the hazard radius from Figure D-2 applied to a point source, results in the envelopes shown in Figure D-3.

Extent of Zone 1: Areas that should be classified as Zone 1 are negligible for above-grade locations. Most Zone 1 locations will be limited to below-grade locations such as pits, sumps, and trenches. Such below grade locations may collect flammable liquids or gases, which can then be transported to other locations by buried conduits unless prevented by proper sealing, purging water traps, or similar measures.

Extent of Zone 2: Use clearances given in Figure D-3.

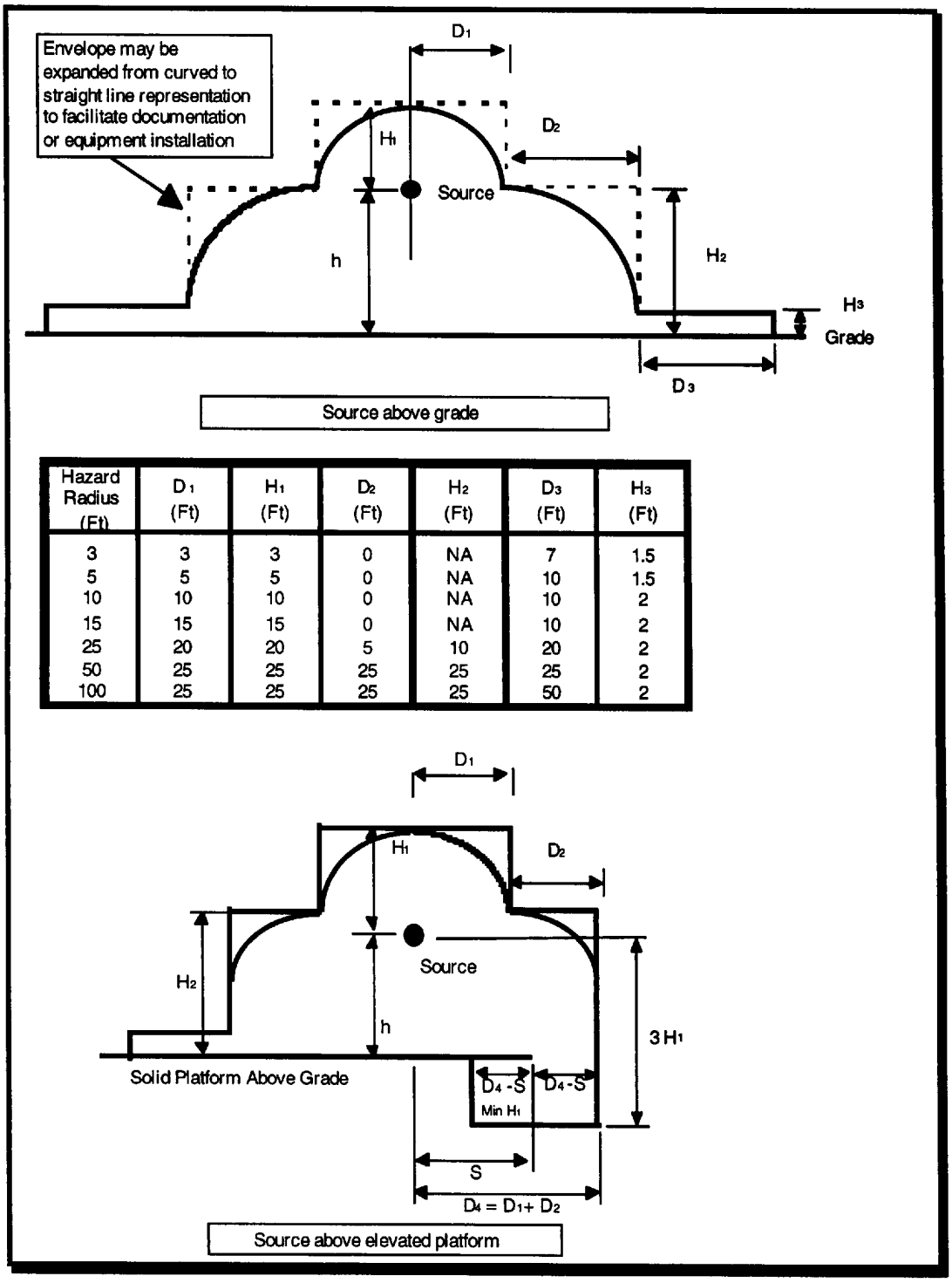
Oftentimes one does not have specific data on the release rate from a source, but additional information is available about the source. As an alternative to using the Category/Release Rate/Hazard Radius approach, the following provides guidance for specific types of sources often found in petroleum process areas.

D.5.3 Pumps—Adequately Ventilated Area

The release rate from process pumps typically is a function of the type of pump, the type of shaft sealing, the physical size of the pump, and the pump seal chamber pressure (the pressure in the cavity internal to the pump shaft seal, also referred to as the stuffing box pressure). Most horizontal shaft pumps have a seal chamber pressure near the pump suction pressure, whereas most vertical pumps have seal chamber pressures near pump discharge pressure. Although pump seal chamber pressure tends to be the driving force behind a release, the pump seal technology often creates the restriction that determines the release rate. For some pumps typically used around very hazardous materials, the seals may be designed with dual sealing chambers, buffer gases, and other detection and alarm technology such that even under abnormal circumstances the seal would not be considered a source of release. Table D-1 provides guidance in determining the hazard radius for various types of pumps.

D.5.4 Equipment Containing Medium and Low Pressure Restrictions (Orifices, Drains, etc.)

Table D-2 applies to any type of potential source in a medium or low pressure system that has a restriction orifice or similar restriction to reduce the rate of release of the source.



Hazard Radius (Ft)	D_1 (Ft)	H_1 (Ft)	D_2 (Ft)	H_2 (Ft)	D_3 (Ft)	H_3 (Ft)
3	3	3	0	NA	7	1.5
5	5	5	0	NA	10	1.5
10	10	10	0	NA	10	2
15	15	15	0	NA	10	2
25	20	20	5	10	20	2
50	25	25	25	25	25	2
100	25	25	25	25	50	2

Figure D-3—Adequately Ventilated Process Area With Heavier-Than-Air Gas or Vapor Source Located Near or Above Grade

Table D-1—Pumps Handling Heavier-Than-Air Gases or Vapors Located in Non-Enclosed Adequately Ventilated Process Areas

Pumps	Category	Low Flow <100 gpm			Medium Flow 100–500 gpm			High Flow >500 gpm			← Pump Flow Rate
Low = <100 psig Medium = 100 to 500 psig High = >500 psig →		Low Pressure	Medium Pressure	High Pressure	Low Pressure	Medium Pressure	High Pressure	Low Pressure	Medium Pressure	High Pressure	← Seal Chamber Pressure
Standard Pump	1	15	25	50	25	50	100	25	50	100	Hazard Radius (ft).
	2	10	15	25	10	25	50	15	25	50	
	3	3	10	15	5	10	25	15	15	25	
High Technology Low Seal Emissions Pump	1	5	10	15	5	10	25	10	10	25	
	2	3	5	10	3	5	10	5	10	10	
	3	3	3	5	3	3	5	5	5	10	

Table D-2—Determining Hazard Radius for Sources With Restrictions for Heavier-Than-Air Gases or Vapors

	Hazard Radius for Restrictions			
	Restriction Diameter (inches)			
Category	.125"	.25"	.5"	1"
1	25	50	100	—
2 or G	10	25	50	100
3	3	5	5	10

Table D-3—Atmospheric Vents and Drains Handling Heavier-Than-Air Gases or Vapors

Ventilation Rate at Ambient Conditions (ft^3/ hr)	Hazard Radius (ft)
Less than 300	10
300—3,000	25
3,000—6,000	50

D.5.5 Compressors

For reciprocating, centrifugal and axial flow compressors handling heavier-than-air gases or vapors, the recommended hazard radius is 50 feet except:

The radius may be reduced to 25 feet for pressures below 20 bar (abs) (291 psia) and shaft diameters of 2" or less.

For diaphragm compressors, the hazard radius may be reduced to 10 feet. Note, however, any vents or drains at the location must be considered separately.

Advanced seal technology may allow a reduced hazard radius if so determined by good engineering judgment.

D.5.6 Instrument and Process Vents and Drains to Atmosphere

Table D-3 applies to atmospheric process vents discharging a heavier-than-air gas or vapor at a velocity of 500 ft/sec or less.

D.5.7 Flanges and Valves

Many flanged joints are rarely broken, for example, only during major maintenance work, and then typically at intervals of two or more years. If there is any leakage from these joints, it is likely to be small. Depending upon the nature of the facility, the level of maintenance, and past experience, a nominal hazard radius of 0 to 3 feet. from the periphery of the flange or valve may be assumed for such joints on well-maintained systems provided there are no factors that could increase leakage (for example—pressure or thermal shocks, including thermal shocks caused by rain, or excessive piping loads on the flanged joints). For certain flanges that offer a higher probability of leakage, such as those around filter manways, vessel manways, and heat exchanger heads that require bundle pulling, one should consider increasing the hazard radius as shown in Table D-4.

Table D-4—Flanges and Valves Containing Heavier-Than-Air Gases or Vapors With a Higher Probability of Leakage

Fluid Category	Hazard Radius (ft)
1	10
2 or G	10
3	5

Note: That area classification does not consider catastrophic or rare failures such as the failure of a gasket due to freezing or over-pressuring.

D.6 Determining the Hazard Radius for Sources Handling Lighter-Than-Air Gases and Vapors

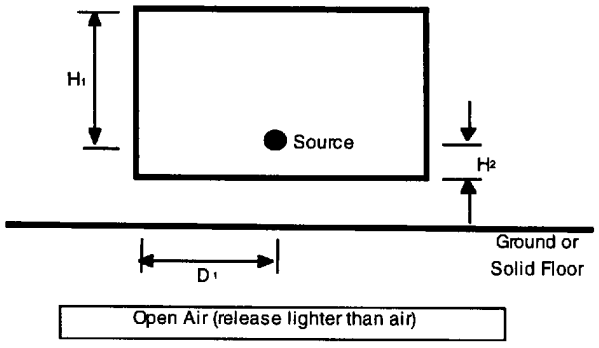
The following recommendations and guides apply to sources handling lighter-than-air gases and vapors.

D.6.1 Point Source Located Above Grade

Figure D-4 depicts the recommended hazard radius for "point" sources containing lighter-than-air gases or vapors.

D.6.2 Compressors

For both reciprocating and axial flow compressors, the recommended hazard radius for lighter-than-air releases is 15 feet.



Hazard Radius (Ft)	H_1 (Ft)	D_1 (Ft)	H_2 (Ft)
30	50	30	20
15	25	15	10
10	15	10	10
5	5	5	5

Figure D-4—Hazard Radius for Point Sources Containing Lighter-Than-Air Gases or Vapors

D.7 Application to Inadequately Ventilated Areas

For sources located in inadequately ventilated areas, the extent of the classified location not only is a factor of the volatility of the gas or vapor released, the velocity of the release, and the rate of the release, but it also is (perhaps, even more important) a function of the degree of ventilation, the ability to detect hydrocarbon releases, and the ability to respond to hydrocarbon releases. The methodology presented in Appendix D of API RP 505 is NOT recommended for applications in enclosed or inadequately ventilated areas. In addition to API RP 505, other sources of information pertaining to the classification of enclosed and inadequately ventilated areas can be found in the following references:

NFPA[15]

NFPA 497 *Recommended Practice for Classification of Class I Hazardous (Classified) Locations in Chemical Process Areas*

The Institute of Petroleum, London[16]

IP 15 *Institute of Petroleum, Area Classification Code for Petroleum Installations*

IEC[17]

IEC 79-10 *Electrical Apparatus for Explosive Gas Atmospheres, Classification of Hazardous Areas*

[15]National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.
[16]The Institute of Petroleum, London, 61 New Cavendish Street, London W1M 8AR, England.
[17]International Electrotechnical Commission, 3 rue de Varembé, P.O. Box 131, 1211 Geneva 20, Switzerland.

APPENDIX E—PROCEDURE FOR CLASSIFYING LOCATIONS

Appendix E is intended to provide an outline of the basic procedures required to classify a location. It is not all inclusive, but combined with sound engineering judgment, should offer guidance to individuals classifying locations.

E.1 Introduction

The following procedure requires answering a series of questions. An affirmative answer to either question in Paragraph E.2 verifies the likely existence of a hazardous (classified) location. Boundaries of locations may be determined by applying the recommendations of the preceding sections and referring to appropriate figures in Sections 8 through 14, as applicable. Each room, section, or area should be considered individually in determining its classification. Initial planning should focus on grouping of sources to allow unclassified locations for electrical equipment installations.

Note: Final determinations of classification should involve coordinated efforts between process engineers, facility design engineers, fire and safety specialists, instrumentation engineers, and electrical engineers.

E.2 Step 1—Need for Classification

E.2.1 The need for classification of a location is indicated by an affirmative answer to either of the following two questions:

1. Are flammable liquids, gases, or vapors handled, processed or stored in or adjacent to the area?
2. Are combustible liquids at temperatures above their flash points likely to be handled, processed, or stored in or adjacent to the area?

Note: For exceptions, see Section 6.2.4.

E.3 Step 2—Assignment of Classification

E.3.1 Assuming an affirmative answer from Step 1, the questions in E.3.2 and E.3.3 should be answered to determine the degree of classification (Zone 0, Zone 1, or Zone 2).

E.3.2 Zone 0 locations normally are dictated by an affirmative answer to any one of the questions that follow:

1. Is an ignitible atmospheric concentration of gas or vapor likely to exist continuously in the location?
2. Is an ignitible atmospheric concentration of gas or vapor likely to occur in the location frequently (greater than approximately 10% of the time) because of maintenance, repairs, or leakage?

Note: Specific piping and tubing systems described in 6.2.4.1 are excluded from this consideration.

E.3.3 After Zone 0 locations have been determined, Zone 1 locations usually may be distinguished by an affirmative answer to any one of the following questions:

1. Is an ignitible atmospheric concentration of gas or vapor likely to exist in the location under normal operating conditions? (See E.3.2 if ignitible concentrations are likely to exist continuously.)
2. Is an ignitible atmospheric concentration of gas or vapor likely to occur in the location frequently because of maintenance, repairs, or leakage (See E.3.2 if ignitible concentrations are likely to exist greater than approximately 10% of the time.)
3. Would a failure of process, storage, transfer or similar equipment likely cause an electrical system failure that would create an ignition source (e.g., electrical arcing) simultaneously with the release of ignitible concentrations of gas or vapor?
4. Is flammable liquid or gas handled, processed or stored in an inadequately ventilated location?

Note: Specific piping and tubing systems and storage containers described in 6.2.4.1 are excluded from this consideration.

5. For flammable liquids with heavier-than-air vapors, is ventilation inadequate to ventilate all areas (particularly floor areas) where flammable vapors might collect?
6. For lighter-than-air gases, are roof or wall openings inadequately arranged to ventilate all areas (particularly ceiling areas) where gases might collect?

E.3.4 After Zone 0 and Zone 1 locations have been determined, Zone 2 locations usually may be distinguished by an affirmative answer to any one of the following questions:

1. In a system containing flammable liquids or gases in an adequately ventilated location, can the liquid or gas escape from potential sources (such as atmospheric relief valves, or pump seals) as a result of an abnormal condition?

Note: Specific piping and tubing systems described in 6.2.4.1 are excluded from this consideration.

2. Is the location adjacent to a Zone 1 location without separation by vaportight walls or barriers?

Note: In some cases, communications of flammable gases or vapors between adjacent locations can be prevented by adequate positive-pressure ventilation from a source of clean air. Reference 6.4.4.

3. If positive mechanical ventilation is provided, could failure or abnormal operation of the ventilating equipment permit ignitible concentrations of gas or vapor to enter or accumulate in the location?

E.4 Step 3—Extent of Classified Locations

Reference 6.4, 7.1, 7.2, and 7.3. Reference also Sections 8 through 14, as applicable.

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E.5 Step 4—Determination of Group

Reference 5.5 to determine the proper group.

E.6 Documentation

E.6.1 All areas designated as hazardous (classified) locations should be properly documented. This documentation should be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location. Documentation should include, as a minimum, for all areas that are classified: (1) the Class, (2) the Zone, and (3) the gas or gas group(s). It may be desirable also to include the maximum permissible operating temperature or temperature range for electrical equipment in the area, the specific liquid(s), gas(es) or vapor(s) that may be present and other information.

E.6.2 The customary means of documenting this information is with an area classification drawing, a plan view drawing of the location depicting: a) the major process or other equipment and components that may be the release source of flammable gases or vapors, or flammable liquids to the atmosphere; b) the boundaries of the various area classifications; and c) other information (i.e., information on ventilation) necessary to properly classify a location. Elevations or sections are desirable where different classifications apply at different elevations. This documentation will serve as a record of the original classifications and will serve as a guide when future additions or revisions to the facility are considered.

ANNEX F—(INFORMATIVE). ALTERNATE VENTILATION CRITERIA (IEC 79-10, MOD)

F.0 Introduction

The purpose of this annex is to assess the degree of ventilation and to define ventilation conditions by means of explanations, examples and calculation, so giving guidance on the design of artificial ventilation systems, since these are of paramount importance in the control of the dispersion of releases of flammable gases and vapors.

The methods developed allow the determination of the Zone Classification by:

a. Estimating the minimum ventilation rate required to prevent significant build-up of an explosive atmosphere and using this to calculate a hypothetical volume, V_z, which, with an estimated dispersion time, t, allows determination of the degree of ventilation. It is not intended that these calculations be used to determine the extent of the hazardous areas;

b. determining the Zone Classification from the degree and availability of ventilation and the grade of release.

Although primarily of direct use in indoor situations, the concepts explained may assist in outdoor locations—for example, by determination of the application of Table F.1.

F.1 Natural Ventilation

This is a type of ventilation that is accomplished by the movement of air caused by the wind, by temperature gradients, or by both. In open air situations, natural ventilation will often be sufficient to ensure dispersal of any explosive atmosphere that arises in the area. Natural ventilation may also be effective in certain indoor situations (for example, where a building has openings in its walls or roof).

Note: For outdoor areas the evaluation of ventilation normally should be based on an assumed minimum wind speed of 0.5 m/s, which will be present virtually continuously. The wind speed frequently will be above 2 m/s.

Examples of natural ventilation:

a. Open air situations typical of those in the chemical and petroleum industries—for example, open structures, pipe racks, pump bays and the like;

b. an open building that, having regard to the relative density of the gases or vapors involved, has openings in the walls, roof, or both, so dimensioned and located that the ventilation inside the building, for the purpose of area classification, can be regarded as equivalent to that in an open air situation;

c. a building that is not an open building but which has natural ventilation (generally less than that of an open building) provided by permanent openings made for ventilation purposes.

F.2 Artificial Ventilation

The air movement required for ventilation is provided by artificial means—for example, fans or extractors. Although artificial ventilation is mainly applied inside a room or enclosed space, it can also be applied to situations in the open air to compensate for restricted or impeded natural ventilation due to obstacles.

The artificial ventilation of an area may be either general or local and, for both of these, differing degrees of air movement and replacement can be appropriate.

With the use of artificial ventilation it is possible to achieve:

a. Reduction in the extent of zones;

b. shortening of the time of persistence of an explosive atmosphere;

c. prevention of the generation of an explosive atmosphere.

Artificial ventilation makes it possible to provide an effective and reliable ventilation system in an indoor situation. An artificial ventilation system that is designed for explosion protection should meet the following requirements:

a. Its effectiveness should be controlled and monitored;

b. consideration should be given to the classification immediately outside the exhaust system discharge point;

c. For ventilation of a hazardous area, the ventilation air normally should be drawn from a non-hazardous area;

d. before determining the dimensions and design of the ventilation system, the location, grade of release and release rate should be defined.

In addition, the following factors will influence the quality of an artificial ventilation system:

a. Flammable gases and vapors usually have densities other than that of air; thus they will tend to accumulate near to either the floor or ceiling of an enclosed area, where air movement is likely to be reduced;

b. changes in gas density with temperature;

c. impediments and obstacles may cause reduced, or even no air movement—i.e., no ventilation in certain parts of the area.

Examples of general artificial ventilation:

a. A building that is provided with fans in the walls, roof, or both to improve the general ventilation in the building;

b. an open air situation provided with suitably located fans to improve the general ventilation of the area.

Examples of local artificial ventilation:

a. An air/vapor extraction system applied to an item of process equipment that continuously or periodically releases flammable vapor;
b. a forced ventilation system applied to a small, ventilated local area where it is expected that an explosive atmosphere may otherwise occur.

F.3 Degree of Ventilation

The effectiveness of the ventilation in controlling dispersion and persistence of the explosive atmosphere will depend upon the degree and availability of ventilation and the design of the system. For example, ventilation may not be sufficient to prevent the formation of an explosive atmosphere, but may be sufficient to avoid persistence of an explosive atmosphere.

The following three degrees of ventilation are recognized:

F.3.1 High Ventilation (VH)

Can reduce the concentration at the source of release virtually instantaneously, resulting in a concentration below the lower explosive limit. A zone of small (even negligible) extent results.

F.3.2 Medium Ventilation (VM)

Can control the concentration, resulting in a stable situation in which the concentration beyond the zone boundary is below the LEL while release is in progress and where the explosive atmosphere does not persist unduly after release has stopped.

The extent and type of zone are limited to the design parameters.

F.3.3 Low Ventilation (VL)

Cannot control the concentration while release is in progress or and/or cannot prevent undue persistence of a flammable atmosphere after release has stopped.

F.4 Assessment of Degree of Ventilation and its Influence on the Hazardous Area

The size of a cloud of flammable gas or vapor and the time for which it persists after release stops can be controlled by means of ventilation. A method for evaluating the degree of ventilation required to control the extent and persistence of an explosive atmosphere is described below.

It should be appreciated that the method is subject to the limitations described and therefore gives only approximate results. The use of the safety factors should, however, ensure that the results obtained err on the side of safety. The application of the method is illustrated by a number of hypothetical examples.

The assessment of the degree of ventilation first requires the knowledge of the maximum release rate of gas or vapor at the source of release, either by verified experience, reasonable calculation or sound assumptions.

F.4.1 Estimation of Hypothetical Volume V_z

The theoretical minimum ventilation flow rate to dilute a given release of flammable material to the required concentration below the lower explosive limit can be calculated by means of the formula:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} \qquad \text{(F1)}$$

Where:

$(dV/dt)_{min}$	is the minimum volumetric flowrate of fresh air (volume per time, m^3/s);
$(dG/dt)_{max}$	is the maximum rate of release at source (mass per time, kg/s);
LEL	is the lower explosive limit (mass per volume, kg/m^3);
k	is a safety factor applied to the *LEL*; typically: k = 0.25 (continuous and primary grades of release); and k = 0.5 (secondary grades of release).
T	is the ambient temperature (in Kelvins).

Note: For converting LEL (vol%) to LEL (kg/m^3), the following formula may be used for normal atmospheric conditions as given in 1.1:

$$LEL\ (kg/m^3) = 0.416 \times 10^{-3} \times M \times LEL\ (vol\%)$$

Where:

M	is the molecular mass (kg/kmol).

With a given number of air changes per unit time, *C*, related to the general ventilation of the area, a hypothetical volume V_z of potentially explosive atmosphere around the source of release can be estimated using the following formula:

$$V_z = \frac{(dV/dt)_{min}}{C} \qquad \text{(F2)}$$

Where:

C	is the number of fresh air changes per unit time (s^{-1});.

Formula (F2) would hold for an instantaneous and homogeneous mixing at the source of release given ideal flow conditions of the fresh air. In practice, such ideal situations will generally not be found—for example, because of possible impediments to the air flow, resulting in badly ventilated parts of the area. Thus, the effective air exchange at the source of release will be lower than that given by *C* in formula (F4),

leading to an increased volume V_z. By introducing an additional correction (quality) factor, f, to formula (F2), one obtains:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} \quad \text{(F3)}$$

Where:

f denotes the efficiency of the ventilation in terms of its effectiveness in diluting the explosive atmosphere, with f ranging from $f = 1$ (ideal situation) to, typically, $f = 5$ (impeded air flow).

The volume V_z represents the volume over which the mean concentration of flammable gas or vapor will be either 0.25 or 0.5 times the *LEL*, depending on the value of the safety factor, k, used in formula (F2). This means that, at the extremities of the hypothetical volume estimated, the concentration of gas or vapor will be significantly below the *LEL*, i.e., the hypothetical volume where the concentration is above the *LEL* would be less than V_z.

F.4.2 Enclosed Area

For an enclosed area, C is given by:

$$C = \frac{dV_{tot}/dt}{V_o} \quad \text{(F4)}$$

Where:

dV_{tot}/dt is the total flow rate of fresh air, and
V_O is the total volume being ventilated.

F.4.3 Open Air

In an open air situation, even very low wind speeds will create a high number of air changes. For example, consider a hypothetical cube with the dimensions of a few meters in an open area. In this case a wind speed of approximately 0.5 m/s will provide an air exchange rate of more than 100/h (0.03/s).

In a conservative approximation using C = 0.03/s for an open air situation, a hypothetical volume V_z of potentially explosive atmosphere can be obtained by using formula (F5):

$$V_z = \frac{(dV/dt)_{min}}{0.03} \quad \text{(F5)}$$

Where:

dV/dt is in volume units per second, and
0.03 is the number of air changes per second.

However, because of the different dispersion mechanism, this method will generally result in an overlarge volume. Dispersion is normally more rapid in an open air situation.

F.4.4 Estimation of Persistence Time *t*

The time (t) required for the average concentration to fall from an initial value X_o to the *LEL* multiplied by k after the release has stopped can be estimated from:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} \quad \text{(F6)}$$

Where:

X_o is the initial concentration of the flammable substance measured in the same units as the *LEL* (i.e., % vol or kg/m³). Somewhere in the explosive atmosphere, the concentration of the flammable may be 100% vol (in general, only in the very close vicinity of the release source). However, when calculating t, the proper value for X_o to be taken depends on the particular case, considering among others the affected volume as well as the frequency and the duration of the release, and for most practical cases it seems reasonable to take a concentration above *LEL* for X_o;
C is the number of air changes per unit time;
t is in the same time units as C, i.e., if C is the number of air changes per second, then the time t will be in seconds;
f is a factor to allow for imperfect mixing (see formula (F3). It varies from 5 (for example, for ventilation with air entering through cracks and a single exhaust opening), to about 1 (for example, for ventilation with air entering through a perforated coiling and multiple exhausts);
ln is the natural logarithm (i.e., 2.303 $\log_{10}$);
k is a safety factor related to the *LEL*—see formula (F2).

The numerical value of t obtained by equation (F6) by itself does not constitute a quantitative means of deciding on the zone type. It provides additional information that has to be compared with the time scale of the particular process and situation.

F.4.5 Estimation of Degree of Ventilation

A continuous grade of release normally leads to a Class I, Zone 0, a primary grade to Class I, Zone 1 and a secondary grade to Class I, Zone 2. This may not always be true because of the effect of ventilation.

In some cases, the degree and level of availability of ventilation may be so high that in practice there is no hazardous area. Alternatively, the degree of ventilation may be so low that the resulting zone has a lower zone number (i.e., a Class I, Zone I hazardous (classified) location from a secondary

grade source). This occurs, for example, when the level of ventilation is such that the explosive atmosphere persists and is dispersed only slowly after the gas or vapor release has stopped. Thus, the explosive atmosphere persists for longer than would be expected for the grade of release.

The volume V_z can be used to provide a means of rating the ventilation as high, medium or low. The persistence time t can be used to decide what degree of ventilation is required for one area to comply with the definitions of Class I, Zones 0, 1or 2.

The ventilation may be regarded as high (VH) when the volume V_z is very small or even negligible. With the ventilation in operation, the source of release can be regarded as not producing an explosive atmosphere, i.e., the surrounding area is non-hazardous. However, there will be an explosive atmosphere, albeit of negligible extent, close to the source of release.

In practice, high ventilation can generally be applied only to a local artificial ventilation system around a source, to small enclosed areas, or to very low release rates. Firstly, most enclosed areas contain multiple sources of release. It is not good practice to have multiple small hazardous areas within an area generally classified as non-hazardous. Secondly, with the typical release rates considered for area classification, natural ventilation is often insufficient even in the open. Furthermore, it is normally impracticable to ventilate artificially larger enclosed areas at the rates required.

The volume V_z does not give any indication of the time for which the explosive atmosphere would persist after release has stopped. This is not relevant in the high ventilation (VH) case, but is a factor in assessing if the ventilation is medium (VM) or low (VL).

Ventilation regarded as medium (VM) should control the dispersion of the release of flammable vapor or gas. The time taken to disperse an explosive atmosphere after release has stopped should be such that the condition for either a Class I, Zone 1 or Class I, Zone 2 is met, depending on whether the grade of release is primary or secondary. The acceptable dispersion time depends on the expected frequency of release and the duration of each release. The volume V_z will often be less than the volume of any enclosed area. In this case it may be acceptable to classify only part of the enclosed area as hazardous. In some cases, depending on the size of the enclosed area, the volume V_z can be similar to the enclosed volume. In this case, all of the enclosed area should be classified as hazardous.

If the zonal concept is not met, then the ventilation should be regarded as low (VL). With low ventilation, the volume V_z will often be similar to or greater than the volume of any enclosed area. Low ventilation (VL) should not generally occur in open air situations except where there are restrictions to air flow (for example, in pits).

F.5 Availability of Ventilation

The availability of ventilation has an influence on the presence or formation of an explosive atmosphere. Thus the availability (as well as the degree) of ventilation needs to be taken into consideration when determining the type of zone.

Three levels of availability of the ventilation should be considered:

a. good—ventilation is present virtually continuously;
b. fair—ventilation is expected to be present during normal operation. Discontinuities are permitted provided they occur infrequently and for short periods;
c. poor—ventilation that does not meet the standard of fair or good, but discontinuities are not expected to occur for long periods.

Ventilation that does not even meet the requirement for "poor" availability must not be considered to contribute to the ventilation of the area.

F.5.1 Natural Ventilation

For outdoor areas the evaluation of ventilation should normally be based on an assumed minimum wind speed of 0.5 m/s, which will be present virtually continuously. In which case the availability of the ventilation can be considered as "good."

F.5.2 Artificial Ventilation

In assessing the availability of artificial ventilation, the reliability and the availability of the ventilation equipment (for example, standby blowers) should be considered. Good availability will normally require, on failure, automatic start-up of standby blower(s). However, if provision is made for preventing the release of flammable material when the ventilation has failed (for example, by automatically closing down the process), the classification determined with the ventilation operating need not be modified; that is, the availability may be assumed to be good.

F.6 Practical Guide

The effect of ventilation on the Zone Classification can be summarized in Table F-1. Some calculations are included in F.7.

Table F-1— Influence of Ventilation on Zone Classification

Grade of Release	Ventilation						
	Degree						
	High			Medium			Low
	Availability						
	Good	Fair	Poor	Good	Fair	Poor	Good, Fair or Poor
Continuous	(Zone 0 NE) Non-Hazardous[1]	(Zone 0 NE) Zone 2[1]	(Zone 0 NE) Zone[1]	Zone 0	Zone 0 + Zone 2	Zone 0 + Zone 1	Zone 0
Primary	(Zone 1 NE) Non-Hazardous[1]	(Zone 1 NE) Zone 2[1]	(Zone 1 NE) Zone 2[1]	Zone 1	Zone 1 + Zone 2	Zone 1 + Zone 2	Zone 1 or Zone 0[3]
Secondary[2]	(Zone 2 NE) Non-Hazardous[1]	(Zone 2 NE) Non-Hazardous[1]	Zone 2	Zone 2	Zone 2	Zone 2	Zone 1 and even Zone 0[3]

[1]Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone that would be of negligible extent under normal conditions.

[2]The Zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release; in which case, the greater distance should be taken.

[3]Will be Zone 0 if the ventilation is so weak and the release is such that in practice an explosive atmosphere exists virtually continuously (i.e., approaching a "no ventilation" condition).

Note: "+" signifies "surrounded by."
Zone 0", "Zone 1", and "Zone 2" are understood to be preceded by "Class 1."

F.7 Calculations to Ascertain the Degree of Ventilation

Calculation No. 1

Characteristics of release	
Flammable material	toluene vapor
Source of release	flange
Lower explosion limit (*LEL*)	0.046 *kg/m³* (1.2% vol.)
Grade of release	continuous
Safety factor, *k*	0.25
Release rate, $(dG/dt)_{max}$	2.8 x 10^{-10} *kg/s*
Ventilation characteristics	
Indoor situation	
Number of air changes, *C*	1/*h*, (2.8 x 10^{-4}/*s*)
Quality factor, *f*	5
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{2.8 \times 10^{-10}}{0.25 \times 0.046} \times \frac{293}{293} = 2.4 \times 10^{-8} m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{5 \times 2.4 \times 10^{-8}}{2.8 \times 10^{-4}} = 4.3 \times 10^{-4} m^3$$

Time of persistence:

Time of persistence is not applicable to a continuous release.

Conclusion:

The hypothetical volume V_z, is reduced to a negligible value.

The degree of ventilation is considered as high with regard to the source.

Calculation No. 2

Characteristics of release	
Flammable material	toluene vapor
Source of release	failure of flange
Lower explosion limit (*LEL*)	0.046 kg/m^3 (1.2% vol.)
Grade of release	secondary
Safety factor, k	0.5
Release rate, $(dG/dt)_{max}$	2.8 x 10^{-6} kg/s
Ventilation characteristics	
Indoor situation	
Number of air changes, C	1/h (2.8 x 10^{-4}/s)
Quality factor, f	5
Ambient temperature, T	20°C (293 K)
Temperature coefficient, (T/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{2.8 \times 10^{-6}}{0.5 \times 0.046} \times \frac{293}{293} = 1.2 \times 10^{-4} m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{5 \times 1.2 \times 10^{-4}}{2.8 \times 10^{-4}} = 2.2 m^3$$

Time of persistence:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} = \frac{-5}{1} ln \frac{1.2 \times 0.5}{100} = 25.6h$$

Conclusion:

The hypothetical volume V_z is significant, but can be controlled.

The degree of ventilation is considered as medium with regard to the source on this basis. However, any release would persist and the concept of Class I, Zone 2 may not be met.

Calculation No. 3

Characteristics of release	
Flammable material	propane gas
Source of release	can-filling nozzle
Lower explosion limit (LEL)	0.039 kg/m^3 (2.1% vol.)
Grade of release	primary
Safety factor, k	0.25
Release rate, $(dG/dt)_{max}$	0.005 kg/s
Ventilation characteristics	
Indoor situation	
Number of air changes, C	20/h (45.6 x 10^{-3}/s)
Quality factor, f	1
Ambient temperature, T	35°C (308 K)
Temperature coefficient, (T/293 K)	1.05

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{0.005}{0.25 \times 0.039} \times \frac{308}{293} = 0.6 m^3/s$$

Evaluation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{1 \times 0.6}{5.6 \times 10^{-3}} = 1.1 \times 10^2 m^3$$

Time of persistence:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} = \frac{-1}{20} ln \frac{2.1 \times 0.25}{100} = 0.26h$$

Conclusion:

The hypothetical volume V_z is significant, but can be controlled.

The degree of ventilation is considered as medium with regard to the source based on this criterion. With a persistence time of 0.26 h, the concept of Class I, Zone 1 may not be met if the operation is repeated frequently.

Calculation No. 4

Characteristics of release	
Flammable material	ammonia gas
Source of release	evaporator valve
Lower explosion limit (*LEL*)	0.105 kg/m^3 (14.8% vol.)
Grade of release	secondary
Safety factor, k	0.5
Release rate, $(dG/dt)_{max}$	5×10^{-6} kg/s
Ventilation characteristics	
Indoor situation	
Number of air changes, C	15/h, (4.2×10^{-3}/s)
Quality factor, f	1
Ambient temperature, T	20°C (293 K)
Temperature coefficient, (T/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{5 \times 10^{-6}}{0.5 \times 0.105} \times \frac{293}{293} = 9.5 \times 10^{-5} m^3/s$$

Estimation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{1 \times 9.5 \times 10^{-5}}{4.2 \times 10^{-3}} = 0.02 m^3$$

Time of persistence:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} = \frac{-1}{15} ln \frac{14.8 \times 0.5}{100} = 0.17h(10min)$$

Conclusion:

The hypothetical volume V_z is reduced to a negligible value.

The degree of ventilation is considered as high with regard to the source. However any equipment located adjacent to the valve should be suitable for Class I, Zone 2 (See Table F-1).

Calculation No. 5

Characteristics of release	
Flammable material	propane gas
Source of release	compressor seal
Lower explosion limit (*LEL*)	0.039 kg/m^3 (2.1% vol.)
Grade of release	secondary
Safety factor, k	0.5
Release rate, $(dG/dt)_{max}$	0.02 kg/s
Ventilation characteristics	
Indoor situation	
Number of air changes, C	2/h, (5.6×10^{-4}/s)
Quality factor, f	5
Ambient temperature, T	20°C (293 K)
Temperature coefficient, (T/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{0.02}{0.5 \times 0.039} \times \frac{293}{293} = 1.02 m^3/s$$

Estimation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{5 \times 1.02}{5.6 \times 10^{-4}} = 9,200 m^3$$

Time of persistence:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} = \frac{-5}{2} ln \frac{2.1 \times 0.5}{100} = 11.4h$$

Conclusion:

In a room of 10 m x 15 m x 6 m, for example, the hypothetical volume V_z would extend beyond the physical boundaries and would persist.

The degree of ventilation is considered as low with regard to the source.

Calculation No. 6

Characteristics of release	
Flammable material	methane gas
Source of release	pipe fitting
Lower explosion limit (*LEL*)	0.033 kg/m^3 (5% Vol)
Grade of release	secondary
Safety factor, k	0.5
Release rate, $(dG/dt)_{max}$	1 kg/s
Ventilation characteristics	
Outdoor situation	
Minimum wind speed	0.5 ms
Resulting in an air exchange, C	>3 x 10^{-2}/s
Quality factor, f	3
Ambient temperature, T	15°C (288 K)
Temperature coefficient, (T/293 K)	0.98

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{1}{0.5 \times 0.033} = 59.3 m^3/s$$

Estimation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{3 \times 59.3}{3 \times 10^{-2}} = 5930 m^3$$

Time of persistence:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} = \frac{-3}{0.03} ln \frac{5 \times 0.5}{100} = 370 s (\text{maximum})$$

Conclusion:

The hypothetical volume V_z is significant, but can be controlled, and would not persist.

The degree of ventilation is considered as medium with regard to the source.

Calculation No. 7

Characteristics of release	
Flammable material	toluene vapor
Source of release	failure of flange
Lower explosion limit (*LEL*)	0.046 *kg/m³* (1.2% vol.)
Grade of release	secondary
Safety factor, *k*	0.5
Release rate, $(dG/dt)_{max}$	6 x 10^{-4} *kg/s*
Ventilation characteristics	
Indoor situation	
Number of air changes, *C*	12/*h* (3.33 x 10^{-3}/s)
Quality factor, *f*	2
Ambient temperature, *T*	20°C (293 K)
Temperature coefficient, (*T*/293 K)	1

Minimum volumetric flow rate of fresh air:

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{k \times LEL} \times \frac{T}{293} = \frac{6 \times 10^{-4}}{0.5 \times 0.046} \times \frac{293}{293} = 26 \times 10^{-3} m^3/s$$

Estimation of hypothetical volume V_z:

$$V_z = \frac{f \times (dV/dt)_{min}}{C} = \frac{3 \times 26 \times 10^{-3}}{3.33 \times 10^{-3}} = 23.4 m^3$$

Time of persistence:

$$t = \frac{-f}{C} ln \frac{LEL \times k}{X_o} = \frac{-2}{12} ln \frac{1.2 \times 0.5}{100} = 0.85 h (51 min)$$

Conclusion:

The hypothetical volume V_z is significant, but can be controlled.

The degree of ventilation is considered as medium with regard to the source. Based on this persistence time, the concept of Class I, Zone 2 would be met.

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